

SANDIA REPORT

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Style Guide (Mechanical) For Technical Writers

Larry S. Lopez

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STYLE GUIDE (MECHANICAL) FOR TECHNICAL WRITERS

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ABSTRACT

The need for consistency and for a centralized guide in which certain mechanical aspects of style can be readily found led to this manual. Because style is a highly personal skill that depends as much on "ear" as it does on correct usage of grammar, only the really troublesome aspects of grammar have been discussed.

ACKNOWLEDGMENT

My sincere thanks to my colleagues of Divisions 3151 and 3152 for their honest and frank appraisal of this guide. In several meetings held to evaluate the contents, these professionals were immensely helpful; while sympathetic, they were also openly critical of errors and inconsistencies. Their single aim was and is a quality product that would reflect the high standards of writing toward which Sandia Laboratories strives.

CONTENTS

| | <u>Page</u> |
|---|-------------|
| Introduction | 7 |
| Major Components of a Report | 10 |
| 1. Preliminary Data | 10 |
| 2. Body of the Report | 13 |
| 3. Back Matter | 17 |
| 3.1 References | 17 |
| 3.2 Appendix | 41 |
| 3.3 Glossary | 41 |
| 3.4 Bibliography | 42 |
| 3.5 Index | 44 |
| 4. Additional Information | 45 |
| 4.1 Footnotes | 45 |
| 4.2 Figures and Tables | 47 |
| 4.3 Numbers | 51 |
| 4.4 Abbreviations | 55 |
| 4.5 Equations | 56 |
| 4.6 Copyright Release | 57 |
| 5. Troublesome Trivia | 58 |
| 5.1 Jargon | 58 |
| 5.2 Hyphens | 61 |
| 5.3 Nouns, Verbs, and Adjectives | 62 |
| 5.4 Things to Consider | 63 |
| References | 66 |
| APPENDIX A - Guidelines for Abstracts and Summaries | 67 |
| APPENDIX B - Report Format | 71 |
| APPENDIX C - Samples of Reference Formats | 75 |
| APPENDIX D - Abbreviations of Periodical Titles | 81 |
| APPENDIX E - Letter Requesting Copyright Release | 87 |
| APPENDIX F - How Engineers and Scientists Write | 91 |
| APPENDIX G - Proofreaders' Marks | 101 |
| APPENDIX H - Equations | 105 |
| Bibliography | 117 |
| A. Annotated Authorities | 117 |
| B. Other Authorities | 120 |
| Index | 121 |

STYLE GUIDE (MECHANICAL) FOR TECHNICAL WRITERS

Introduction

This guide is just that -- a guide; it would be presumptuous to tell a writer how to write. Since each style manual differs slightly from every other manual, no single one is THE AUTHORITY. Yet each publishing house, each press, each college in every university has its preferred guide. The purpose is consistency; once the mechanics have been agreed on, every writer thereafter can feel that he is consistent with organization policy.

For this manual, the entire bibliography was carefully checked and double checked. To an amazing degree all manuals agreed on most points. When they did disagree, it was always on minor details. For instance, Berenson and Colton feel that a bibliographical entry should be identical in format to a reference; that is, rather than periods to separate the different elements they prefer parentheses. But they base this deviation on the shaky ground that students and professors have better things to do than memorize two different forms for saying the same thing.

In cases where several authorities disagreed, I balanced the inconsistencies as best I could, basing my decision on modern practice. I also gave more than due consideration to the Government Printing Office (GPO) Style Manual because it is the authority for government or government-related work. If it came to a choice between the GPO and, say, the Chicago Style Manual, I leaned toward the GPO -- so long as it had grammatical reason on its side and if there was no conflict with scholastic standards. For instance, Turabian likes to capitalize "a. m." and "p. m." (ante and post meridiem). The GPO uses lower case. Because there is no scholastic or grammatical reason that they be capitalized, and since Chicago allows both, I felt that the GPO should be recommended; besides, A. M. is also the abbreviation for anno mundi.

On the other hand, the GPO hyphenates all words that include "quasi." Chicago does not. In this case, not only do all modern, unabridged dictionaries back Chicago, but grammatical accuracy also decides in the latter's favor.

Again, if the GPO was clearly in error, I ignored it. For example, in 1967, the term "degree kelvin (°K)" was officially dropped and replaced by plain "kelvin." The word apparently never reached the editors of the GPO.

My primary authority on the format for references, footnotes, and bibliography was Campbell/Ballou. I have yet to encounter a guide that even comes close to theirs in thoroughness, completeness, and adherence to the highest standards of scholarship.

Except for jargon, hyphenation, and a few vexatious examples, I have not attempted to comment on style or grammar. Not only are there many excellent books on the subject (I especially recommend Tichy), but it would be patronizing to suggest style to an experienced and university-trained writer.

The field of hyphenation, however, is such an untamed wilderness that a concise, readily available guide, based on numerous authorities, is always useful. Jargon is another field that, I believe, deserves special attention because it is the very antithesis of clear and understandable communication:

"The majority of people living today in civilized countries cannot read and write freely in size language [e.g., mathematics] just as the majority of people in the times of Wycliff and Luther were ignorant of Latin in which religious controversy was carried on. The modern person has got to learn the language of size in self-defense, because no society is safe in the hands of its clever people."

-Lancelot Hogben

Egyptian and Babylonian priests were just such clever people who carefully, methodically, and scientifically studied the cold facts of nature, then issued a batch of mumbo jumbo to the riff raff. Thus, for centuries they were able to control kings and nations. The modern equivalents of the ancient priests are scientists and engineers who deal continuously with size language. Their jargon is an effort, conscious or otherwise, to retain this knowledge within a select group. Most writers are cognizant of this; there is probably no technical writer who has not contacted an author to clarify the meaning of a term or acronym. More often than not, he is met with outright hostility and the curt response that "anyone in the field knows what it means." Clear and understandable writing is the natural enemy of such parochialism. Persons outside "the field" have not only the right, but often the need to know what is going on inside the field -- they pay the taxes and they fund the projects.

A close cousin of jargon is pedantry. Using such terms as "utilize, sufficient, due to, via, or succinct" as a substitution for "use, enough, because, through, or brief" is stuffy and, rather than adding to clarity, actually obscures meaning. It is no fault of the words themselves, but an author who habitually uses them also tends to use ten words where one will do. Almost instinctively, he uses nouns to carry the action of the sentence, and is addicted to the passive voice:

Notification of authorities was made by the guards. (Better: The guards notified the authorities.)

DUNAGIN'S PEOPLE / by Ralph Dunagin



("Reproduced by courtesy of Field Newspaper Syndicate.")

In the format of this guide I have taken some liberties but all were taken for the sake of clarity. Clarity, after all, is the prime criterion to which form and style are servants. A law of writing states that "if it can be misunderstood, it WILL be misunderstood" (sometimes, even if it cannot, it is!).

Most mechanical situations in writing can be resolved by consulting various authorities. Dictionaries and thesauri are the handiest, but there are several excellent style manuals available. Each writer has his favorites; in the bibliography are some of mine. The authority for controversial entries in this guide is included in parentheses following the entry and refers to the bibliography.

Most writers, editors, and supervisors of the Technical Writing and the Publications Services Divisions attended seminars where the guide was carefully discussed, paragraph by paragraph. The published results have been agreed on; they are the standard to which Sandia reports should adhere. If an author/writer decides to deviate from these guidelines, he should enclose a special note to the editors or compositors stating his intention to do so. Otherwise the editor will presume that an error or omission has been made and will change the draft copy to conform with the guidelines.

Since even style guides dealing with mechanics are dynamic artifacts, I have provided blank pages at strategic points for jotting down new standards, exceptions, special cases, deviations, and practices in certain disciplines.

Major Components of a Report

1. PRELIMINARIES

Preliminary Data

Data that are preliminary to the body of the report include such items as the abstract, acknowledgment, foreword, preface, contents, frontispiece, and summary. Placement and arrangement of these items is mostly a matter for compositors, but their content is the responsibility of the writer.

1.1 ABSTRACT

Abstract -- All reports require an abstract -- a microversion of the report expressed in about 200 words (refer to Appendix A). It contains no details but deals in entities or, at most, in categories. It tends to be impersonal, but should be written as interestingly as possible for it is used to "hook" the reader into ordering the report or, if on hand, into reading it:

ABSTRACT

The flame-retardant properties of various chemicals have been investigated under laboratory conditions; some novel and surprising

1.2 ACK

Acknowledgment -- An acknowledgment gives credit to persons or agencies who have helped the author in any way, including encouragement; Sandia desires acknowledgment only to those who make professional contributions. Modern usage discourages such words as "The author wishes to thank" If the author wishes to thank, he should do so:

My appreciation to

We, the authors, thank

Foreword -- Very seldom found in a technical report, this word is frequently misspelled "Forward" in the mistaken assumption that it starts off the report. Actually, this "prior word" is inserted by someone other than the author, usually an authority in the field who has read the manuscript and feels compelled to put in a good word or two about the contents or the author. Usually the writer of the foreword is better known in the field than the author and his boost adds authenticity, integrity, and authority to the report.

1.3
FOREWORD

Preface -- The author of the report is responsible for this "prior word." It is seldom included in a technical report unless it is a subsequent edition, a reprint, or a revision. Even then it is included only if the author feels it is absolutely required, since the title page usually gives sufficient information. Only material pertinent to the contents of the report should be entered in the preface.

1.4
PREFACE

Contents -- This item does not bear the words "TABLE OF"; the fact that it is arranged in tabular form presupposes that it is a table. It is not required for reports of less than 12 pages or 5 centerheads.

1.5
CONTENTS

Generally, only centerheads are included in the contents as headings. However, if the author feels sideheads should be listed, they are included as subheadings.

Reference and appendix sections are included in the table of Contents; headings and subheadings are listed exactly as they appear in the text. Figures and tables are each listed separately, with the figure caption and the table titles listed exactly as they appear in the text. When a figure carries a legend, a caption should be developed for the legend and entered in the contents (para 4.2).

Frontispiece -- This item is very rare in a technical report. The frontispiece is generally a photograph or a drawing illustrating the entire text. It is not considered a figure to be numbered. Its title is placed (centered) one space beneath the illustration; three spaces below (also centered) is the all-capitalized word "FRONTISPIECE."

1.6
FRONTISPIECE

1.7
SUMMARY

Summary -- A summary, **the last** of the preliminary data, is sometimes included in a Sandia report (refer to Appendix A). If the author feels compelled to write one, it is more detailed than the Abstract but less than the Introduction. The summary is especially useful in an extremely long report to acquaint the reader with the general contents and arrangement of the text and with significant findings.

1.8
NOMEN

Nomenclature -- For the purpose of this guide, a difference is made between a nomenclature list and a glossary. A glossary consists of full words or clauses whose definitions are generally accepted across a wide range of professions and disciplines. A nomenclature list, on the other hand, usually contains single letters or symbols whose definitions may or may not be generally accepted; the definition given by the author may apply only to his work.

The nomenclature list usually appears at the beginning of the text to acquaint the reader with the definitions the author intends. The nomenclature list (with the centerhead "Nomenclature") is usually composed of Latin and Greek letters and other symbols. The Latin letters, in alphabetical order, precede the Greek, also in alphabetical order. Next come the symbols in alphabetical order according to their English meaning; e. g., % (percent) would follow // (parallels) but precede + (plus).

Body of the Report

The body of the report can be divided into several headings such as dropheads, centerheads, and sideheads (Appendix B). Not all reports will include all these divisions; clarity, as always, is the criterion. Specifications described here apply to typed material. Other formats will be developed when phototypesetting is available.

2. REPORT BODY

Drophead (DH) -- If the report is of normal size, the title of the report, as it appears on the title page, serves as the drophead. If the report is extremely long and contains sections or chapters, the section or chapter headings are DHs.

2.1 DH

The DH is the first item on the first page; it is capitalized and centered. It always appears on a right-hand page:

COMPUTER NETWORKING: A NEW CONCEPT

(or)

SECTION I. CONTROL STATIONS

Centerhead (CH) -- The centerhead appears four spaces below the DH and is centered. All subsequent CHs need not appear at the top of a page but are centered four spaces below preceding text. They should have at least one paragraph or several lines of text between them and the bottom of the page; CHs never appear alone on a page without supporting text. Initials of important words are capitalized:

2.2 CH

COMPUTER NETWORKING: A NEW CONCEPT

Introduction

Separated Sidehead (SSH) -- This heading begins four spaces below the CH and flush with the left margin, is underlined, and has initial letters capitalized. The first line of text begins under the SSH and is indented paragraph fashion. If the information in the CH is to be divided into two or more broad subjects, the divisions are designated by SSHs. However, if the CH information is not to be divided, then the SSH is omitted because there is only

2.3 SSH

one general topic and that is covered by the CH; if the SSH itself is to be divided into subtopics, it always contains introductory text rather than an abrupt break into its subtopics (see below, RI).

COMPUTER NETWORKING: A NEW CONCEPT

Introduction

History of Computing

2.4
RI

Run-In Sidehead (RI) -- This heading begins two spaces below the last line of the introductory text following the SSH. It is included only when SSH material is divided into two or more subjects; it never appears alone.

Only the initial letters are capitalized in an RI title and it is indented five spaces from the left margin, underlined, and followed by a space, a dash or two hyphens, a space, and the first line of text. Subsequent lines of text begin flush with the left margin except for normal paragraphing:

COMPUTER NETWORKING: A NEW CONCEPT

Introduction

History of Computing

The history of computing at Sandia Laboratories can be divided into three phases: beginning, intermediate, and present.

Beginning -- In 1948 . . . computing at . . . and the United States cooperated with

2.5
MORE
DIVISION

Further Division -- Further breakdown of subject matter should be avoided. If absolutely necessary, the different "minisubjects" can be blocked and, in parenthesis, prefaced with numbers if chronology is

to be indicated, or letters if relative importance is to be shown. It is best, however, to use "bullets" to catalogue facts that carry no inherent chronology or importance in relation to each other.

Bullets -- The "bullet" is a special subdivision used to call attention to information that may get lost in the general text. Usually it subdivides an RI but may also appear below any paragraph that needs clarifying. Bullets never appear singly; the subject to be divided must contain at least two subdivisions. The information is typed in reduced measure.

2.6 BULLETS

The bullet mark itself is placed as many spaces from the left margin as the beginning of the RI or its principal paragraph. Two spaces divide the mark from its text. If the sentence that introduces the bullets is a complete statement, it is followed by a colon:

. . . salmonella can be categorized according to their behavior:

- Salmonella choleraesuis are secondary invaders in hog cholera
- Salmonella Hirschfeldii cause enteric fever

If the introductory sentence is not a complete statement, no punctuation follows it:

. . . can be harmful whenever they are

- Ingested, that is, introduced into the body in food, through open wounds, or by breathing
- In contact for an extended time, especially in polluted water which allows their vector to burrow through the skin

Since the format is an aberration of the syllabus style, the initial letter is always capitalized, but bullets are seldom punctuated with a terminal period and are never connected with commas or coordinating conjunctions (Chicago 8.39; Reisman, p 4-13). If, however, they are introduced by a complete sentence and at least one part contains two or more complete statements, they may be punctuated normally. In such a case, it may behoove the writer to rewrite the text and either incorporate the bullet information into the main body or break it up into two or more subparagraphs with (1), (2), (3), or (a), (b), (c).

2.8 NUMBERING

Numbering -- Except for chapter and section headings, subdivisions of a report are not numbered. Chapters and sections are numbered consecutively in arabic numerals.

Reference works, manuals, or procedural guides (such as this) have numbered paragraphs as the author deems convenient for his readers.

References --

3.1
REFERENCES

"The standards of scholarship require that all source material be acknowledged by the writer, not merely as a matter of intellectual honesty but also as a validation of his work. The authority or source for every fact, opinion, or conclusion quoted, literally or otherwise, must be given. Credit for ideas or statements that have been taken from any publication, lecture, interview, or other source should be given in the text or footnotes or in a references-cited section. Giving credit for a borrowed idea is as necessary as acknowledging the source of borrowed words, symbols, or other forms of expression."

-- Campbell/Ballou

An excessive number of references, however, betrays a sense of insecurity, especially if they are used to back up or validate well-known facts. That Columbus discovered America while sailing for the crown of Castile need not be cited. If he executed a few of his soldiers for disobedience, the fact should be cited. That H_2 combined with O forms water need not be cited. That $TiCl_4$ reacting with NH_4OH forms two types of smoke in which atmospheric moisture is replenished should be cited because it is a newly discovered process.

In the following examples, some categories are not included because their rarity in technical and scientific reporting puts them beyond the purview of this guide. Such categories include legal documents, statutory and quasi-statutory material, and literary references such as novels, scripture, classical works, plays, and poems. If citations fall into these categories, the writer may carefully peruse one of the authorities mentioned in the bibliography, especially Campbell/Ballou, or any other favorite.

3.1.1 LOCATION

Location -- References appear in their own section at the end of a Sandia report or, in long reports, at the end of each section in their own subsection. If appendixes contain citations, the reference section follows them; if not, it precedes them.

The same reference can be cited several times throughout the text, even if other works have been interposed. Thus, reference 3, for example, can be cited after 4, 5, 6, etc. This can be done with superscripts or with a note enclosed in parenthesis:

. . . the final word (see Ref 3).

Clarity is the criterion; as long as there is no possibility for confusion, the writer may feel confident that he is on the right track -- if he remains consistent.

3.1.2 METHOD

Method of Citing -- Without exception, a quotation (direct or indirect) must always be cited. A reference is cited in the text with a superscript, usually an arabic numeral:

. . . another source maintains the opposite.³

3.1.2.1 PLACEMENT

As often as possible, the citation is placed at the end of a paragraph, but the end of a sentence is perfectly acceptable. If the writer wishes to indicate that only part of the information contained in a sentence can be attributed to the cited source, it is acceptable to place the superscript at the end of the clause. It is best, however, to recast the sentence so that the cited information appears at the end. In all cases, the citation follows all marks of punctuation except the dash; if it pertains only to information within parenthesis or brackets, the citation is placed within these marks.

3.1.2.2 THREE CITES

More than one citation per sentence should be avoided not only for clarity, but for aesthetic reasons. If multiple citations are absolutely necessary, and if all share in the information contained in the sentence, they should be listed at the end of the sentence. If there are three or fewer, they are separated by spaces -- never commas (GPO 8.56):

. . . When current was applied, the filament
vaporized.^{1 2 3}

If there are more than three citations and they are in consecutive order, a dash can separate the first from the last:

3.1.2.3
OVER THREE

. . . have obtained differing results.⁸⁻¹⁷

If the citations are not inclusive, there is no alternative but to list them in numerical order:

3.1.2.4
NOT IN
ORDER

. . . Radiation was fatal.^{2 5 9 13}

Sometimes different information contained in a single sentence can be attributed to several sources. If the author wants to make clear that each source contributed only a portion, the superscript should appear after the particular clause conveying the information. Because it is unsightly, this practice should be avoided:

3.1.2.5
AFTER MULTIPLE
CLAUSES

. . . When titanium is heated beyond this, it
vaporizes⁹ but if immersed in sodium it can with-
stand almost twice the heat,¹⁷ provided it does not
come in contact with water.³

Format -- Appendix C contains examples of reference formats useful in the reference section. A cited reference begins five spaces in from the left margin. The citation numeral is typed in arabic numerals and is 1/2 linefeed above the baseline; without spacing and on the baseline, the actual reference begins and is typed to the end of the line. All references end with a period. Lines subsequent to the first start flush with the left margin.

3.1.3
FORMAT

Most standard references follow a consistent pattern: name of author (in normal order), title, facts of publication, and ancillary information.

³Conrad O. Jones, The Politics of Waste Isolation (New York: Pergamon Press, 1978), p 233.

However, each category of sources presents a slightly different problem.

Author -- Usually, the first element in the reference is the name of the author, followed by a comma. Rarely, the name of the compiler, editor, or translator may appear first:

3.1.3.1
AUTHOR

- If the book has more than one author but no more than three, they appear in the order listed on the title page, separated by commas:

3.1.3.1a
MULTIPLE AUTHORS

¹²Wendell W. Smith, Lloyd L. Alpaugh,
and Larry S. Lopez,

- A reference is no more than a device that enables the reader to locate cited literature. It is not intended to give notice that a person has published. Therefore, an author who insists on listing every co-author, regardless of number, in order to acknowledge all, should be firmly advised that it is not only counter to Sandia policy, but also tends to degrade professional as well as academic standards. If there are more than three

3.1.3.1b
OVER THREE
AUTHORS

authors, only the first one listed on the title page is identified, followed by the abbreviation "et al" without a separating comma:

¹²Conrad O. Jones et al,

- If the author's name is not included in the title page but it is known, it should be included in brackets:

3.1.3.1c
NAME KNOWN;
UNLISTED

¹²[Wendell W. Smith],

- When the author merely employs an editor, compiler, or translator to modify his work, his own name precedes the title and that of the nonauthor may follow it. In this case, the abbreviation "ed" means "edited by" and is never pluralized to mean "editors":

3.1.3.1d
NONAUTHOR

¹²Conrad O. Jones, The Politics of Waste Isolation, ed Larry S. Lopez

- The name of the editor or compiler comes first when no author is mentioned on the title page or when there is separate authorship of the component parts, chapters, or selections such as in a reader or anthology. If reference is made only to a particular selection, however, the author's name is listed first, followed by the title of the selection in quotations, the underlined title of the book, then the name of the editor (see para 3.1.3.2b).

3.1.3.1e
NO AUTHOR

- If the author is unknown, the reference begins with the title of the work, not with the word "anonymous" or its abbreviation.

3.1.3.1f
AUTHOR UNKNOWN

3.1.3.2
TITLE

Title -- The second element in the reference is the title, underlined (or italicized) usually followed by a space and open parenthesis. The spaces between words are considered to be part of the title and are, therefore, also underlined:

¹²Conrad O. Jones, The Politics of Waste Isolation (. . . .

3.1.3.2a
SUBTITLE

- If a subtitle appears on the title page, it too must be included in the reference. A colon is inserted between this and the title:

¹²Wendell W. Smith, Waste Isolation: A Political Football (. . . .

3.1.3.2b
ARTICLE

- If the reference is a selection in a compilation such as a reader or anthology, the title of the article or selection is followed by a comma and enclosed in quotation marks. This is then followed by the title of the book, underlined solidly, and, after a comma, its editor's name:

¹²Wendell W. Smith, "The Politics of Waste Isolation," Nuclear Pollution: a Ticking Timebomb, ed L. S. Lopez (. . . .

3.1.3.2c
FOREIGN
TITLE

- The translation of a title in a foreign language is enclosed in brackets immediately after the original title and only the original is underlined; titles in European languages are not translated.

¹²Ch'en Shih-ch'i, Ming-tai kuan shou-kung-yeh ti yen-chiu [Studies on government-operated handicrafts during the Ming dynasty]*

* Extracted from Chicago, para 9.108.

3.1.3.3
PUB FACTS

Facts of Publication -- The next element, enclosed in parentheses, contains the facts of publication that enable the reader to obtain the document and to decide its authenticity and age:

3.1.3.3a
EDITION

- The edition number is seldom a problem but it does crop up occasionally. The first edition does not require a number because it is understood to be number 1. All subsequent editions, however, should be identified in abbreviated form and followed by a semicolon:

12 . . . Waste Isolation (2d ed;

3.1.3.3b
REVISION

- If subsequent editions are revisions of the first one, they should be identified as such:

12 . . . Waste Isolation (2d ed rev;

3.1.3.3c
PUBL'N PLACE

- The place of publication is the city where the main editorial offices are located and is usually the first item in the facts of publication. It need not include the state or country unless confusion will result or if the city is not well known. If two cities are mentioned, both are listed; if more, only the first is named. The city is followed by a colon if the publisher is next; if not, it is followed by a comma:

12 . . . Waste Isolation (New York:

3.1.3.3d
NO CITY

- If the place of publication is unknown but the publisher is, the location can usually be determined and it is entered as usual. If there is no city or publisher listed, the abbreviation "np" replaces both:

12 . . . Waste Isolation (np,

- The next item in the facts of publication is the name of the publishing house, followed by a comma:

3.1.3.3e
PUBLISHER

¹² . . . Waste Isolation (New York: Pergamon Press,

- The date is the last item in the facts of publication. Usually only the year is listed, followed by closing parenthesis. If there is no more information in the reference, the parenthesis is followed with a period; if there is more, then a comma:

3.1.3.3f
DATE

¹² . . . (New York: Pergamon Press, 1978),

Ancillary Information -- Sometimes the writer wishes to give additional information that will lead the reader to the exact location of his source or will help him decide whether or not the book is worthwhile reading. This information follows the facts of publication.

3.1.3.4
EXTRA INFO

- Page numbers, if included, follow the facts of publication and are preceded by a comma. A single page is abbreviated "p" and multiple pages "pp"; the number is followed by a period.

3.1.3.4a
PAGE NO.

¹² . . . Pergamon Press, 1978), pp 164-8 . . .

- A final and entirely optional element of a cited reference is the note. A note is an annotation to the preceding information which the author feels is of interest to the reader. The note is a new sentence and, therefore, follows the period after the page number; the first word is initially capitalized:

3.1.3.4b
NOTES

¹² . . . 1978), p 18. Although information on the fauna and flora in the area of the proposed plant is useful, the book is amateurishly written and conclusions are not supported with evidence.

Multiple-Volume Works -- For citation purposes, multiple-volume works come in two categories. One consists of two or more volumes under one general title (multivolume work). The other category consists of works that are independent of each other but are parts of a series such as the Time/Life series The Old West. The author, title, and ancillary information are usually entered exactly as for single-volume works (see 3.1.3). In fact, if chapters or selections in each volume have separate authorship, then the title of the selection is enclosed in quotation marks, the title of the volume is underlined, and it is followed by a comma or a parenthesis, as the case may be (see 3.1.3.2b).

3.1.3.5
MULTIPLE
VOLUME

Information that comes between the title and the facts of publication is intermediate information and it is here that multiple-volume works begin to differ substantially from single-volume works. However, since citing multiple-volume works is a rarity in Sandia technical reporting, the writer is referred to examples in para 3.1.3.5b, Appendix C, and the bibliography (especially Campbell/Ballou).

3.1.3.5a
INTERMEDIATE
INFOR.

- Below are some complete sample references of multiple-volume works. Many more could be presented but only the most common are given (note that under "general title," page numbers are not preceded by "p" or "pp"):

3.1.3.5b
SAMPLES

¹²Wendell W. Smith, Politics of Waste Isolation, IX (New York: Pergamon Press, 1976), 132-45.

GEN'L TITLE

¹²Wendell W. Smith, Politics of Waste Isolation, vol IX of Ramifications of Nuclear Technology (New York: Pergamon Press, 1978), pp 293-392.

INDIV TITLE

(or)

¹²Wendell W. Smith, "Politics of Waste Isolation," Ramifications of Nuclear Technology, vol IX of Modern Sciences (New York: Pergamon Press, 1978), pp 293-394.

SERIES

¹²Wendell W. Smith, The Politics of Waste Isolation, 10 vols., Ramifications of Nuclear Technology, OS, vol II (New York: Pergamon Press, 1978), p 353.

Government Publications -- Most government documents are authored by agencies rather than individuals, some have no definitive titles, and almost all adopt some kind of numbering system. Authorship is therefore listed in descending order of jurisdiction, separated with commas. For example, in the Congress, the House and Senate are subordinate to the parent body, committees are subordinate to the particular house, and subcommittees to the parent committee:

3.1.3.6
GOVT PUBS

¹²US, Congress, House, Committee on Energy, Subcommittee on Nuclear Safety, The Waste Isolation Pilot Plant, Hearing, 93d Congress, 1st Sess, November 20-30, 1978 (Washington: Government Printing Office, 1979), p 58.

A document may be authored by an individual. In such a case, it is handled more or less as if it had been commercially issued, especially if a private firm has done the printing. If a government agency has sponsored the publication, this information also appears, between the title and the facts of publication:

¹²Wendell W. Smith, The Politics of Waste Isolation, US Department of Energy, Publication No 70 (Washington: Government Printing Office, 1978), pp.65-9.

Periodicals and Journals -- The first three elements in journal citations almost always follow the standard format; i.e., author, title of the article enclosed in quotation marks, the usual punctuation, and the underlined title of the journal. The journal title is often abbreviated; for consistency, abbreviations for technical and scientific journals should be based on the Applied Science and Technology Index (Appendix D), or other appropriate publications:

3.1.3.7
JOURNALS

¹²Wendell W. Smith, "The Politics of Waste Isolation," J Nucl Sci,

There are several ways to enter volume numbers and additional information into journal references. These are exemplified by the traditional form, the Modern Language Association form, and the form used in the H. W. Wilson Company Indexes. The last is usually the form used in technical reports and will be the one demonstrated below.

3.1.3.7a
ADD INFO

- Immediately after the journal title, its comma, and a space, the volume number is inserted in arabic numerals, followed by a colon. In mass media publications, such as magazines and newspapers, the volume number may be omitted.

3.1.3.7b
VOL NO.

- If there is an issue number, it comes inside parentheses between the volume number and the colon. If the issue number is included, the month or season is omitted from the facts of publication.

3.1.3.7c
ISSUE NO.

- After the issue number and colon, without spacing, come the page numbers, followed by a comma and a space.

3.1.3.7d
PAGE NO.

- Next comes the date, consisting of the month or season, and the year. The year is followed by a period.

3.1.3.7e
DATE

3.1.3.7f
JOURN SAMPLE

¹²Wendell W. Smith, "The Politics of Waste Isolation," J Nucl Sci, 1:63-5, Spring 1978.

3.1.3.7g
MAG SAMPLE

¹²Wendell W. Smith, "The Politics of Waste Isolation," J Nucl Sci, September 28, 1978, p 23.

3.1.3.7h
NEWS SAMPLE

¹²Wendell W. Smith, "The Politics of Waste Isolation," The Albuquerque Journal, October 12, 1978, p 10, col 5.

(or)

¹²The Albuquerque Journal, October 12, 1978, p 10, col 5.

3.1.3.8
UNPUB

Unpublished Sources -- Unpublished sources include theses, dissertations, scientific papers, manuscripts and report collections, interviews and telephone conversations, speeches, letters, memorandums, etc.

3.1.3.8a
THESES
SAMPLE

¹²Wendell W. Smith, "The Politics of Waste Isolation," (PhD diss, University of New Mexico, 1978), p 28.

3.1.3.8b
SCI PAPERS
SAMPLE

¹²Wendell W. Smith, "The Politics of Waste Isolation," 5th annual meeting of the American Association of Nuclear Engineers, Albuquerque, NM, October 1978.

3.1.3.8c
COLLECT'NS
SAMPLE; PAPERS

¹²Papers on waste isolation (MS in Sandia Laboratories Library, Albuquerque), report by Nuclear Research Division 0001, October 19, 1978. Hereafter this collection cited as PWI.

3.1.3.8d
COLLECT'N;
MS

¹²WIPP reports, Sandia Laboratories, Albuquerque (Sandia Library microfiche copies and microfilm, reels IX-22 and -23).

3.1.3.8e
INTERVIEWS,
PHONES

¹²Statement by Wendell W. Smith, nuclear engineer, personal interview, Sandia Laboratories, Albuquerque, October 12, 1978.

3.1.3.8f
PUB SPEECH

¹²Opinion expressed by Wendell W. Smith, nuclear scientist, in an address, "Politics of Waste Isolation," at Sandia Laboratories, Albuquerque, October 12, 1978 (tape and transcript at Sandia Laboratories library).

3.1.3.8g
LTRS, MEMOS

¹²Based on a personal memorandum between Wendell W. Smith, supervisor of Nuclear Research Division 0001 at Sandia Laboratories Albuquerque, and the author, October 24, 1978.

(or)

¹²Wendall W. Smith to C. O. Jones, "Recent work on the Denial Access System of the ZPPR" (Albuquerque: Sandia Laboratories, Apr 18, 1979). Memorandum.

3.1.3.9
SAND RPTS

Sandia Reports -- The SAND series, follows a standardized format:
author, underlined title, short title, facts of publication.

SPECIAL NOTE: A classified report is never referred to in an unclassified report, not even by its short title.

SAND SAMPLE

¹²Wendell W. Smith, The Politics of Waste Isolation, SAND78-0001 (Albuquerque: Sandia Laboratories, 1978), p 32.

3.1.3.10
CLASSIFIED
DOCs

It is Sandia policy to avoid listing any classified references in an unclassified document scheduled to reach a wide audience, or in one which could conceivably reach audiences wider than originally intended.

It is wise also to avoid listing any document with a limited distribution (such as SDO, SEDO, IDO) or any Internal Memorandum. Those who believe they have a need to know are invited by listings of document numbers and titles to challenge our judgment and seek mandatory review and release of documents by any of several avenues (such as Executive Orders and the Freedom of Information Act).

If an organization feels strongly that classified and limited-distribution documents must be included in references and bibliographies for the sake of completeness or comprehensiveness, then members of that organization should be prepared to justify those classifications and limitations in a manner that will convince reviewers that release should not be granted.

Appendix -- After the main body of the report and the reference section, the appendix appears. Its designation consists of the all-capitalized word "APPENDIX" followed by a space and a capitalized designator letter. The designator is alphabetized in order of appearance and, if called out in the text, the designator immediately follows the clause or sentence that introduces it:

3.2
APPENDIX
3.2.1
PLACEMENT

. . . much extraneous dirt has accumulated (Appendix C).

An appendix is material that supplements but is not considered part of the text. Like the human appendix, it can be separated from the body which, although it might miss the appendix, will not suffer greatly from its removal. If the message in the text will in any way suffer, then somehow the inherent information of the appendix must be incorporated into the body of the report.

3.2.2
CONTENT

If the appendix is part of an already published work, due credit must be given. This is usually done in centered parenthesis, on the Appendix title page:

3.2.3
CREDIT

APPENDIX A

Specification of Alumex - 66

(Excerpts from pamphlet issued by
Jerome F. Stebbins, Inc, Plainview, TX)

Glossary -- In a report that contains many technical terms, a glossary should be included as a courtesy to the general reader. The terms to be defined are arranged in alphabetical order. Each term is fully capitalized and followed by a period; then the term is defined. Each term begins a new line, flush with the left margin. If the definition is longer than one line, subsequent lines are indented five spaces. Unless one or all of the definitions contain more than one complete statement, no terminating period is used. However, if one terminates in a period, all do. The glossary is included in its own section with the centerhead "Glossary of Technical Terms." The section comes between the appendix and the bibliography.

3.3
GLOSSARY

GLOSSARY
EXAMPLE

Glossary of Technical Terms

QUANTIMET. A device that combines electron micro-
scope and computer technology to measure
microscopic particles

SINTERING. Forming a coherent bonded mass by
heating metal powders without melting

3.4
BIBLIO

Bibliography -- Every report with citations should have a reference section. Only lengthy works include bibliographies because most works listed are included in the reference section; the bibliography is more an extra courtesy to the reader than it is a requirement. It should contain all the references cited because it supplements, rather than replaces, the references. It may also contain additional sources to guide the reader to literature which the author believes important or interesting.

3.4.1
FORMAT

Format -- The format for the bibliography differs from that of the references only in listing, arrangement, and in punctuation. No page numbers are listed because the author is calling attention to the entire work.

3.4.1.1
AUTHOR

Author -- Since the citations do not refer to the bibliography, this section is arranged in alphabetical order by surname of author. If there is more than one author, only the surname of the first author is alphabetized and the others are listed in normal order:

Smith, Wendell W. and Larry S. Lopez. Politics of . . .

3.4.1.1a
AUTHOR
MULTIWORKS

- If more than one work by the same author(s) is listed, an 8-space line followed by a period is substituted for the author's name. His works are then listed by date of publication:

Smith, Wendell W. Politics of (June 1976)

_____. Nuclear Proliferation (Jan 1978)

- If the author is not known, the work is alphabetized by the first word of the title, excluding definite or indefinite articles.

3.4.1.1b
UNKNOWN
AUTHOR

Punctuation -- Unlike references, in bibliographies the author, title, and intermediate information are followed by periods and double spacing rather than commas and the facts of publication are not enclosed in parentheses. The first line in an entry begins flush with the left margin and subsequent lines are single-spaced and indented 8 spaces or 16 units:

3.4.1.2
PUNCT'N

Smith, Wendell W. The Politics of Waste Isolation. 2d ed rev. New York: Pergamon Press, 1978.

Categorization -- If a bibliography lists approximately 20 titles or more, it should be divided into categories such as books, periodicals, or government publications. If primary sources are used, two major categories (primary and secondary sources) can also be listed. In such a case, the major categories are preceded by capital letters (A, B, C, etc) in their order of listing. Subcategories are listed in numerical order, designated by arabic numerals. Under the categories or subcategories, the works are listed in alphabetical order by author or title:

3.4.2
CATEGORIES

BIBLIOGRAPHY

A. PRIMARY SOURCES

1. Collected Documents

Smith, Wendell W. The Politics of Waste Isolation

Wallace, Jerry W. Politics vs A Sane Policy of Waste Isolation

2. Letters, Memorandums, and Interviews

Smith, Wendell W. to Jerry W. Wallace.
Telephone conversation dated 24 April
1978

Wallace, Jerry W. Opinion expressed in an
address to the student body of

B. SECONDARY SOURCES

1. Books

Smith, Wendell W. The Politics of

Wallace, Jerry W. Nuclear Proliferation and . . .

2. Periodicals

Smith, Wendell W. "The Politics of Waste
Isolation." Nucl Sci

Wallace, Jerry W. "Nuclear Proliferation."
Albuq Journal

3.5 INDEX

Index -- Except for reference works, an index is rarely necessary in a Sandia report. Indexing is tedious and expensive. The usual method is to wait until the final version of the report has been typed on masters and the review copy approved. Then each and every important term to be indexed is entered onto its own index card and filed alphabetically. Each time the term appears in the text, its page and/or paragraph number is entered on the card. After this procedure is completed, the index section is composed from the set of cards.

Additional Information

Footnotes -- In Sandia reports, footnotes carry only explanatory information and are not to be used as references.

Location -- A footnote, as the name implies, appears at the foot of the page without intruding into the bottom margin. It is separated from the text by a 15-space line placed two linefeeds below the last line of text to be entered on that page. If there is not a full page of text, the full margin has to be left at the foot of the page, the number of lines of footnotes calculated upward from the margin, then two linefeeds, and the 15-space line typed flush with the left margin.

The footnote itself is begun a half linefeed below its symbol or citation number with no space; the symbol is entered eight spaces from the left margin. The entire footnote is single-spaced and lines subsequent to the first are typed flush with the left margin:

*This is usually known as the Xerox effect.

In tables, notes appear directly beneath the table in which they are cited, 2-1/2 spaces below the last line.

Content -- Since Sandia reports contain a reference section, footnotes carry only explanatory information; that is, information that expands data already in the text. This type of information, while helpful in some reports, is an archaic practice to which historians and sociologists are much addicted. Avoid overuse because these notes distract the reader unnecessarily. If it cannot be said in the text, perhaps it should be eliminated altogether. Sometimes, however, the author knows that a few of his readers may not know the meaning of a statement yet he realizes that the vast majority for whom his report is intended do and therefore he does not want to break up his narrative to explain it. As a courtesy to his less knowledgeable readers, he should explain it in a footnote. He should not feel that it is condescending; many a reader will thank him for his thoughtfulness:

4. ADDITIONAL INFO

4.1 FOOTNOTES

4.1.1 LOCATION

4.1.2 TABLES

4.1.3 CONTENT

. . . an analysis previously done on the Quantimet^{*}
in which a sample of

^{*}The Quantimet is a device that combines
electron microscope and computer technology to
measure microscopic particles.

Explanatory notes never appear in the reference section.

4.1.4 FORMAT

Format -- If there are no reference citations, superscript arabic numbers may be used to cite footnotes in the text; they are numbered consecutively throughout the entire report. If it is a very long report, they may be numbered by chapter or section. Notes in a table are designated with a lower-case letter.

4.1.5 OTHER SYMBOLS

If there is a reference section, as there is in most reports, other superscript symbols are used for explanatory footnotes, in the following order: asterisk (*), two asterisks (**), dagger (†), double dagger (‡), section mark (§), parallels (||), etc. These symbols are used anew for each page.

Figures and Tables

Figures -- Figures are graphs, charts, photographs, line drawings, schematics, etc. Each is placed as close after the callout as possible; the exact placement is a matter for the compositor who is guided by specific instructions. However, the writer is responsible for ensuring that the contents are accurate and consistent with the text, that the legend or caption fully describes the contents, and that the callout in the text is at the proper location. As an extra courtesy, the writer can indicate on the margin of the draft copy when the callout for a particular figure or table first appears so that the compositor does not have to struggle to find it.

- Callout. In the text, the figure is called out with its designator that includes the word "Figure" (never abbreviated and always initially capitalized because it is the title) followed by a space and an arabic numeral. The designator is numbered consecutively in order of appearance and the callout immediately follows the clause or sentence that introduces it:

. . . and when the charge explodes, the gap closes (Figure 3).

- Placement. Figures in the appendixes are numbered independently of those in the text and in other appendixes. Their identification number is preceded by the identification letter of the appendix in which they appear; e.g., Figure A-1, Figure B-2, etc. They are not always included in the Contents, depending on the size of the document, the extensiveness of the appendixes, and the preference of the author. On the figure itself, the designation (never abbreviated) is placed three spaces below the figure and, with its caption (for a legend, see below), is centered beneath the figure. The designation is followed by a period, two spaces, and then the caption or legend.

4.2 FIGURES AND TABLES

4.2.1 FIGURES

4.2.1.1 CALLOUT

4.2.1.2 PLACEMENT

4.2.1.3
CAPTION

- **Caption.** A caption is a short description (almost an abbreviated title) of the figure, consisting of a few words. Each important word, as in a title, is initially capitalized:

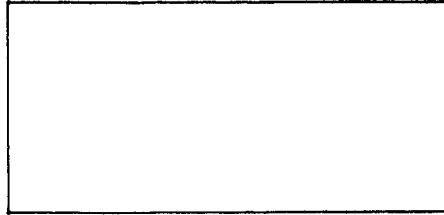


Figure 3. Moment of Closure

4.2.1.4
LEGEND

- **Legend.** A legend is a more lengthy explanation of the contents of the figure. If it consists of approximately five words or more, a caption should be developed; this is entered into the table of Contents. In the remainder of the legend, only the first word in a sentence or proper nouns are initially capitalized. Lines subsequent to the first are single spaced and begin in block fashion immediately under the first letter of the first line:

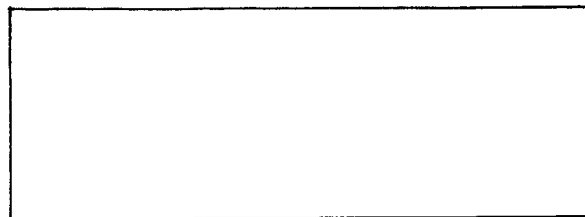


Figure 3. Moment of Closure. Immediately after the charge explodes, the molten metal shoots across the gap in approximately 5 ms.

4.2.2
TABLES

Tables -- A table can be distinguished from a figure by the simple criterion that it can be completely composed on a typewriter and is tabular in form. If lines are drawn to separate columns, they are optional and serve primarily for visual clarity. Anything more complex can be considered a figure.

- Callout. Like figures, a table is placed as close to its callout as possible. Its designation is composed of the word "Table" followed by a space and an arabic numeral. The designation is numbered consecutively in order of appearance; the table callout is placed inside parentheses immediately after the clause or sentence that introduces it:

4.2.2.1 CALLOUT

. . . all data that have been gathered to date (Table 1).

- Placement. On the table itself, the designation is placed above the table and centered. Two spaces below, also centered, is the title with initials of all important words capitalized. Additional information is centered below the title. Three spaces below the title or additional information, as the case may be, the column headings begin, with all initials of important words capitalized. Abbreviations may be used liberally if no confusion results; unusual abbreviations or other complex information may be explained in footnote:

4.2.2.2 PLACEMENT

Table 3

Traffic Congestion in the Southeast Heights
(Average No of Autos; July - Dec 1975)

| Hour of Day | Intersections | | |
|----------------|---------------|-----------|--------|
| | S Mat/Gib | S Ped/Gib | La/Gib |
| 0600 | 302 | 250 | 262 |
| 0700 | 1233 | 1056 | 1138 |
| 0800 | 2356 | 2290 | 2584 |

- Decimals. When decimal numbers are arranged in columnar form, all decimal points are aligned vertically. Also in this case, whole numbers will be followed by a decimal point and a zero (cipher). Partial numbers will be preceded by a zero and a decimal point.

4.2.2.3 DECIMALS

In some tables, however, this may become impractical because of the number of columns and the sheer size of the table. In such a case, the writer should work closely with the editor and compositor to assure consistency.

Numbers

4.3 NUMBERS

Figures vs Words -- As a general rule, numbers below ten should be spelled out and above that, arabic figures should be used. Use figures for related numbers whenever at least one of the numbers in a unit is ten or more; for this purpose, the limiting unit is considered a sentence (GPO 12.5):

4.3.1 SPELL OUT

. . . the number of personnel attending the
lectures varied from 8 to 12.

- Measurements. Units of measure are expressed in figures. However, no matter how great, these quantities do not influence other, unrelated numbers in the limiting unit:

4.3.1.1 MEASUREMENTS

20 mi, 8 ft, 220 V, 20 lb, 30°, 15 mm

(but)

Of the eight men, five received 5 lb each
and three received 3 lb each.

- Ordinal Numbers. Ordinal numbers follow the same rule as cardinals. However, ordinal and cardinal numbers in the same unit are treated separately:

4.3.1.2 ORDINALS

The fifth bus carried 25 persons.

Of the multitude who applied, five were
chosen to march in the 13th annual parade.

Pluralization -- Modern usage pluralizes figures as if they were words omitting the apostrophe before "s":

4.3.2 PLURALS

1930s, five 20s, two 100s, CDC 6600s

4.3.3 SYMBOLS

Symbols -- Symbols of measurements that sit close to the figure are repeated after each dimension; abbreviations and full words only if they are different (GPO 10.6):

15° to 65°; ±2 to ±7; 30 μ and 50 μ .

but

2x4-ft board

2 in x 4 in x 4 ft

- Signs such as +, -, \times , or \div are usually closed against their figure measurements. If a symbol will cause confusion, as in the third example above, it is separated with a space.
- In scientific writing, the degree symbol (°) is preferred to the word "degree" following a figure (GPO 10.5).

4.3.4 SEPARATING 1000s

Spaces vs Commas -- Some countries use commas and others use periods to separate groups of three digits in numbers over 1000. Those countries that use periods, use commas rather than decimal points; Great Britain uses a raised period. The international scientific community has neatly sidestepped the issue by using spaces and Sandia policy goes along (Chicago 8.35; ASTM, p 6; OPM II, p 21; BTL, pp 23, 68):

Correct: 35 128 33 028 147

Incorrect: 35,128 33,028,147

4.3.5 MIL UNITS

Military Units -- Except for "Corps" which is expressed in roman numerals, military units are always designated in arabic figures:

8th Army, 50th Regiment, 7th Fleet, but
XIX Corps

Fractions, Decimals, Percents -- Except at the beginning of a sentence, fractions, decimals, and percentages are expressed in figures. Scientific usage prefers the percentage symbol (%) to the word "percent." In decimals, except in denoting the calibre of gun bores, probabilities, statistics, or relationships, if there is no unit, a cipher is supplied:

4.3.6
FRACTIONS
DECIMALS
PERCENTS

0.268, 1.0, 0.30 but .30 calibre

Beginning of Sentence -- At the beginning of a sentence, numbers are spelled out even if subsequent numbers are not:

4.3.7
BEGIN
SENTENCE

Fifty-six grams of lead mixed with 32
grams of

Ratios -- Ratios are expressed in figures separated with a colon (tight up):

4.3.8
RATIO

1:1, 1:1 000 000, 1:50

Time -- Except for general divisions such as centuries, decades, and quarters, units of time are expressed in figures:

4.3.9
TIME

6 yr, 20 d, 9 mo, 8 wk

- When only the month, year, or season is given, a comma is not used between the smaller and larger time division:

4.3.9a
MONTH AND
YEAR

April 1932

4.3.9b
ABBREV

- Abbreviating the year should be avoided; if done, it should be preceded with an apostrophe:

Those graduating in '76, '77, and '78 will

4.3.9c
FY

- In abbreviating the fiscal year, no apostrophe is required; since common usage eliminates the periods and other symbols indicating the missing letters in Fiscal Year, it would be begging the grammatical question to include them in the year:

FY 1978 if the entire year is listed, but
FY78 if year is abbreviated.

4.3.9d
HOURS

- Hours of the day are separated from their minutes with colons. Morning or evening are indicated by lower-case "am" or "pm" without spacing. The word "o'clock" is never used with those abbreviations. Internationally, the less-ambiguous 24-hr clock is used; it is also preferred in scientific writing.

. . . the train departs at 1345 and returns at
0400.

4.3.9e
MIL TIME

- The military community uses the 24-hour clock but often, for affectation, appends a redundant "hours" to the time; when encountered, it should be mercilessly deleted:

Reveille, reveille! It is now zero-six-hundred-
hours! Chow down at zero-six-thirty-hours!

(Note that "four bells" in Navy jargon does not mean "four o'clock." Actually, four o'clock is eight bells!)

- Large divisions such as centuries and decades, are not capitalized (Chicago 8.15):

4.3.9f

The nineteenth century; the twenties

Abbreviations

4.4

ABBREVIATIONS

Expansion -- Except for such generally accepted abbreviations as PhD, USA, USSR, and radar, abbreviations should always be expanded the first time used, no matter how common, even such familiar ones as DOE, DOD, STTF, LASL. Every writer knows that anybody in that favorite exclusion area, "the community," will know what the engineer means. But, as a courtesy to noncommunity readers who do, in fact, have a need to read the report, all abbreviations should be expanded.

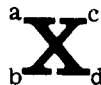
4.4.1

EXPANSION

Like jargon, abbreviations and acronyms are a device to limit the readership and, if not the readership, the understanding to a select few. The technical writer should not allow the assumed irritation and sometimes downright hostility of the author to cow him into not expanding an abbreviation. Utmost clarity for all readers is the criterion.

Technical abbreviations, whenever possible, should conform to official Sandia publications. The following is taken directly from such a publication:²

The placement of subscripts and superscripts around atomic elements is often a perplexing question. Therald Moeller in Inorganic Chemistry writes that, according to the INTERNATIONAL UNION OF CHEMISTS, the most nearly unambiguous system is the following (element X):



Position a = the MASS number
 Position b = NUCLEAR CHARGE
 Position c = ION CHARGE (if any)
 Position d = NUMBER OF ATOMS PRESENT
 in a molecule

Those SI abbreviations based on a person's name (volt, hertz, pascal, etc) have the first letter capitalized (V, Hz, Pa, M). Normally, abbreviations are not pluralized or punctuated with a period except at the end of a sentence.

4.4.2 PLURALIZING

Pluralizing -- When pluralizing all-capital abbreviations, a lower-case "s" is appended without an apostrophe:

. . . in path analysis, OCEs and ACEs are identified by

4.4.3 CAPITALIZING

Capitalizing -- For lower-case abbreviations, the same rule applies unless confusion will arise; in that case an apostrophe is used. Unless they are an important element of a title, such abbreviations as ac, dc, hf, vhf, etc, are not capitalized.

4.4.4 PUNCTUATION OF ABBREV

Punctuation of Abbreviation -- For consistency in Sandia reports, no abbreviation, whether technical or not, is punctuated with a period unless confusion will result. The sentence should be restructured so that the confusion is avoided; only reluctantly should a period be applied.

4.5 EQUATIONS

Equations

Equations are a special category of expressions prevalent in scientific writing. A writer or a typist need not know what a mathematical expression means, but he can tell if it is not only balanced, but also correctly stated by following the rules explained in Appendix H. Taken directly from the Office Procedures Manual, Section II, "Secretarial Aids," this appendix is primarily intended for typists. However, the writer in trying to determine clarity will find it a valuable aid.

Equations are numbered consecutively in arabic numbers enclosed in parentheses. The number is placed to the right of the identified equation, flush with the right margin. Equations contained in appendixes are preceded with the Appendix letter.

(A1), (B2)

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4.6
COPYRIGHT
RELEASE

5.
TROUBLESOME
TRIVIA

Troublesome Trivia

5.1
JARGON

Jargon --

"A detached fragment of the terrestrial lithosphere, whether of igneous, sedimentary, or metamorphic origin, and whether acquiring its approximation to sphericity through hydraulic action or other attrition, when continuously maintained in motion by reason of the instrumentality of gravitational forces constantly acting to lower its center of gravity, thus resulting in a rotational movement around its temporary axis and with its velocity accelerated by any increase in the angle of velocity, is, because of abrasive action produced by the incessant but irregular contact with the terrain, temporarily prevented from accumulations on its external surface of any material stemming from a class (Musci) of bryophytic plants."³

That anybody would go to this extent to say that a rolling stone gathers no moss is amusing. What is not so amusing is that many scientists and engineers are, in fact, addicted to the vice of extraneous verbosity (Appendix F).

English is exceptionally rich in semantics, a fact appreciated especially by those who speak several additional languages. It can be subtle, it can be plain; it can be obscure, it can be clear; it can be circumspect, it can be direct. Unfortunately, some scientists and engineers specialize in the first categories of these pairs.

Usually, the fewer the words and more active the voice, the clearer the meaning:

"I'm gonna stomp a mudhole in him and stomp it dry." Can a scientist describe a process so directly? It just ain't dignified to use such simple language to describe such serious subjects.

Jargon has its place--or so it's been said. However, while I concede the benefit of the doubt, I cannot think of a single instance where it is necessary; where good ol' plain English wouldn't do the job better.

By jargon I do not mean specialized language which precisely describes a process or an instrument for which there is no other word: retrorockets, nose cone, binary digit, minicomputers, etc. Rather, jargon is that pretentious, long-winded language used by those who are educated beyond their intelligence and are hell-bent to prove it to whoever has the patience (and stomach) to wade through their attempts at befogging an issue.

Almost every writing office has a list of "Buzzwords," each different but all carrying the same message:

| 1 | 2 | 3 |
|----------------|----------------|-------------|
| interdependent | involvement | objectives |
| compatible | motivation | utilization |
| incremental | effectiveness | capacity |
| optimized | integration | management |
| optional | transitional | options |
| quality | digital | contingency |
| synchronized | organizational | mobility |
| responsive | monitored | transition |
| total | integrated | projection |
| systematized | reciprocal | capability |

To use, select at random a word from the first column, one from the second, and one from the third and you can make such authoritative statements as "Incremental transitional capability."⁴

These lists would not be half so hilarious if they were far off the mark. They are not. Consider the following sentence, plucked directly out of an ordinary report, written by a scientist who otherwise insists in the utmost and painstaking precision in his scientific measurements:

"... to obtain earth penetrator penetration environmental, stability, and depth performance data."

Engineers, technicians, and scientists are also much addicted to an aberration--an abomination, really--of the English language which should be struck down without mercy whenever encountered. That is the vice of transforming nouns and sometimes adjectives into verbs then back into nouns by using the

shamelessly wanton and compliant suffix "-ize." Why the practice is so widespread is a mystery to most writers who love and admire the directness of the English language. Perhaps the author feels it sounds more educated, more serious--certainly it is more ponderous. The following are just a few examples taken randomly from a few reports. Hundreds more could be supplied:

| <u>Noun/Adjective</u> | <u>Verb</u> | <u>Noun</u> |
|-----------------------|--------------|------------------|
| Pallet | Palletize | Palletization |
| Container | Containerize | Containerization |
| Layman [sic] | Laymanize | Laymanization |
| Rigid | Rigidize | Rigidization |
| Weapon | Weaponize | Weaponization |
| Rugged | Ruggedize | Ruggedization |
| Flexible | Flexibilize | Flexibilization |

Another, related, practice is using the equally complaint suffix "-wise" to transform any word into an adverb; this is as outlandish as teenagers use of "-ish" to express approximately:

the missile traveled ballisticwise . . .
the steel tip of the drill worked diamondwise
(Compare: I'll see you around sevenish, he
looked a bit Clark Gableish.)

Hyphens

5.2 HYPHENS

The Hyphen in Compounds -- Because "the world of the hyphen is anarchic" (Bernstein, p 366), many authors of scientific and technical subjects have trouble with hyphenation. The easiest place to resolve the question is a good dictionary. However, not all rules or examples can be found there. The next step is to consult one of the authorities mentioned in the bibliography. Yet, there are still some situations that either remain outside the purview of even those experts or are so sketchily covered that they are obscure.

5.2.1 HYPHEN

Unit Modifier -- What is the difference between "1 cc of mercury" and "a 1-cc measurement of mercury?" Why hyphenate "a 10-mm gap" but not "a gap of 10 mm?" In most cases, this is simple to explain. In the hyphenated examples, both participating words of the compound act as a single adjective and the adjective immediately precedes the noun it modifies (GPO, 6.15; ASTM, 3.5.1.5).

5.2.1.1 UNIT MODIFIER

Quasi -- "Galactical Instruments is a quasi laboratory specializing in quasi-scientific toys." In the one case, quasi is a full adjective preceding and modifying its noun; it is, therefore, not hyphenated. In the other case, it is a compound adjective modifying a noun. This is true even if it follows the noun (Chicago, Table 6.1). The GPO (6.34), on the other hand, always hyphenates quasi. However, Chicago is recommended because all modern unabridged dictionaries agree with it. (Sometimes quasi may be a prefix forming a noun as in quasiparticle.)

5.2.1.2 QUASI

General -- Normally, if not in the dictionaries, hyphenation should be avoided and the words either run together if they both form an adjective, or left separated and distinct -- if there is no resulting confusion (GPO, 6.16). If the least ambiguity results, however, the hyphen should be inserted in the proper place:

5.2.2 GENERAL

- "Since the GC710 has only a single channel memory" The context indicates that the memory is single channel rather than multichannel, not that it is the only channel memory available. Thus the hyphen belongs between "single" and "channel"

- "The four bellows retaining rods were analyzed"
Several meanings are possible but the context reveals that

- there is only one bellows, not four;
- there are four rods;
- these rods retain the single bellows.

Somehow the hyphen must show that the rods do the retaining. Thus, we obtain "The four bellows-retaining rods"

- A similar situation may arise in ". . . a view of the silver activation detector." Context shows that the detector is not made of silver but rather detects the activation of silver. Thus, "silver-activation detector."
- Some writers may hesitate over "5 inch thick shield of lead" or over "50 mm deep filtration solution." Follow the same rule as for "60-year-old maverick" (Chicago; Table 6.1).
- There are no hyphenated Americans (GPO; 6.21).

5.3 NOUNS, VERBS, AND ADJECTIVES

Nouns, Verbs, and Adjectives

5.3.1 NOUNS

Nouns -- With Teutonic precision, the Germans call the noun a Dingwort, that is, a "thing-word." An excessive number of Sandia authors try to transform nouns into "do-words;" that is, verbs and adjectives (see Appendix F). This practice is so prevalent and so varied that hundreds of examples are readily available.

5.3.2 NOUN/ ADJECTIVES

Nouns as Adjectives --

- ". . . The safeguards element performance criteria must be met"

(The string of nouns sounds extremely important but what does it mean? Evidently that some kind of criteria must be met. But what?)

- ". . . depends on process and measurement simulation models.

- ". . . Drive motor maintenance access is provided.
- ". . . four circuits for cubicle door magnetic switch excitation."

Nouns as Verbs --

5.3.3
NOUN/VERBS

- ". . . Additional costs for implementation of . . ."
(Better: Additional costs to implement)
- ". . . a physical move of plutonium is to take place."
(Better: Plutonium is to be moved.)
- "Installation of the two SSMS was accomplished. . ."
(Better: The two SSMS were installed.)

Things to Consider -- Certain anachronisms and instances of clumsy writing recur with annoying frequency in scientific and technical reports. Since the country is heading toward the metric system and the scientific community is becoming more international, the following should be carefully considered:

5.4
CONSIDERATIONS

- The degree mark (°) when giving the temperature in kelvins: the term "degrees kelvin (°K)" was officially discarded in 1967. Kelvin is the name of the graduation itself:

5.4.1
KELVINS

14 K, 375 K (but 36°F, 20°C)

- Such abbreviations as cc, sq ft: it is best to use superscripts of the powers of 10

5.4.2
SQUARES/ CUBES

cm³, ft², in²

- Cycles per second: best to use "hertz".

5.4.3
CYCLES

Incorrect: Megacycles per second
Correct: Megahertz (MHz)

5.4.4
NEWTONS

- Kilogram-force: use newtons (N).

5.4.5
METRIC TON

- Metric ton: the ton is a US measure equaling 2000 lb. The metric ton equals 1000 kilograms. Without the "metric," the metric ton is given the French spelling "tonne." However, international usage prefers megagrams (Mg).

5.4.6
ROENTGEN

- The roentgen as a unit of radiation: abbreviated R. This expression to indicate units of radiation has now given way to the rad. Rad, originally an abbreviation for "radiation absorbed dose," is now abbreviated rd.

5.4.7
METRICS/LITRE

- The litre as a unit of quantity: even in metric countries the litre represents two distinct measurements. Although the international scientific community reluctantly accepts it because of its widespread use, the cubic decimeter (dm^3) is preferred in scientific literature. Incidentally, the abbreviation, in the United States, is L rather than lower case l as used internationally. The reason for this was possible confusion with the numeral one.⁵ Sandia requires the spelling "litre" and "metre" rather than "liter" or "meter." (OPM II).

5.4.8
TORR

- The torr as a unit of pressure of stress: use the pascal (Pa).

5.4.9
MULTIPLE
SUPERSCRIPTS

- Superscripts: when citing multiple references, a space, not a comma, is placed between the citation numbers (GPO: 8.56):

Correct: . . . data from several sources.^{1 5 9}
Incorrect: . . . data from several sources.^{1, 5, 9}

5.4.10
PATRONIZING

- Patronizing language: such terms as "of course . . ."; "it is clear that . . ."; "it is obvious that . . ."; "interestingly enough, . . ."; "five (5) dollars"; etc, are patronizing and, if taken seriously, insulting. If it is obvious and clear, then saying so will not make it any more obvious unless the author feels that he is brighter than his reader

and he must point out things that to him (the author) flow naturally from the preceding data. Also, what may be interesting enough to the author may not be so to the reader.

- The micron: this unit of length is no longer accepted in SI computations; use instead the micrometre (μm).

5.4.11
MICRON
 - SI discourages the use, in scientific writing, of the prefixes hecto-, deka-, deci-, and centi-; rather use the "preferred" prefixes--those that represent 10 raised to the power of 3 or multiples thereof (ASTM 2.5).

5.4.12
HECTO, DEKA
ETC
 - Commas in a series: a comma appears before the last conjunction joining the last unit in a series, unless words connected with conjunctions form a recognized unit:

5.4.13
COMMAS; SERIES
- For supper I had steak, potatoes, and bread.
 For breakfast I had coffee, ham and eggs,
 bread and butter, pancakes, and fruit.
- Data: data can be either singular or plural; datum is seldom used in English. If "information" can be substituted for "data," then it is singular; if "facts" can be substituted, then it is plural (Tichy, p 149).

5.4.14
DATA
 - Billion: avoid the word "billion;" it means a thousand million in the US, but a million million elsewhere. Use instead the prefixes "giga-" or "tera-".

5.4.15
BILLION
 - Bit: originally an abbreviation for BInary digiT, it is now accepted as a word on its own merit and abbreviated "b." Since it is a measurement, it is preceded by a figure (8 bits, 6-bit word, 3000 bits). When preceded by metric prefixes [kilobit (kb), megabit (Mb), terabit (Tb)], it becomes a compound word.

5.4.16
BIT

References

¹ Elsa Toom, ed, Applied Science and Technology Index (New York: H. W. Wilson Company). Issued annually.

² Larry S. Lopez, Abbreviations for Technical Writers, SAND78-1341 (2nd ed rev; Albuquerque: Sandia Laboratories, 1979).

³ The Sandia Computing Newsletter, October 1978, p 5.

⁴ L. J. Peter, The Peter Principle: Why Things Always Go Wrong (New York: William Morrow & Co, 1969), pp 133-5.

⁵ Metric Reporter, 4:26 (December 24, 1976).

APPENDIX A

Guidelines for Abstracts and Summaries

GUIDELINES FOR ABSTRACTS AND SUMMARIES

For efficient review and evaluation of Sandia reports, informative abstracts and full summaries are essential. Informative abstracts, as opposed to descriptive abstracts, are preferred for Sandia reports. In fact, ERDA Manual Chapter 3201 makes the informative abstract a requirement. An informative abstract contains a concise statement of the purposes of the report, what was learned in the study being reported, and what conclusions were reached. (A descriptive abstract, on the other hand, is merely a condensation of the topics in the table of contents.*) The following suggestions are designed to assist report writers in the preparation of these report elements.

Traditionally, certain information is expected in informative abstracts and in summaries:

Abstracts:

1. State the purpose of the study, the objectives, or the subject treated. (This should not be merely a repetition of the title, but should supplement it.) Allude to the work of others if your work is a direct outgrowth, but include no references. Use a word to characterize the scope of treatment: brief, comprehensive, preliminary, experimental, theoretical.
2. State the method of attack, parameters, and equipment involved. Especially note unusual approaches or unique adaptations of equipment.
3. Report newly observed facts, experimental or theoretical results (expected and unexpected), degree of accuracy, significances. Do not keep the results a mystery.
4. Note related work that is planned or needs to be done as a follow-on.
5. Format it all into one paragraph. Use no illustrations, charts, tables, or footnotes. Use full sentences, and the active voice in the third person, if possible: "Results (research, experiments, tests, data, investigation) "show" (suggest, indicate, demonstrate, reveal, confirm, contradict, evince) that . . . (See samples on back.) Some prefer the first person forms ("I" or "we"). Do not allude to specific figures or paragraphs in the report. Convert to metrics.

Summaries:

In practice, summaries tend to be complete but concise recapitulations of the major points of an entire report — an uncomplicated adding up of the whole in miniature to aid the memory or the understanding of the reader and to show relationships between points. A summary answers the question, "What is the report all about?" If the information in the report is rather concentrated, the summary may be longer than for a report of equal length developed in more leisurely fashion. If the summary occurs in the "front matter" of the report (an increasingly favored position), the writer may be obliged to provide more orientation for the reader than if it is placed at the end. It is urged that every Sandia report carry a summary in the front matter, following the table of contents. (In short reports, the abstract may serve as the summary.)

It may be worth considering the differences between a summary and a conclusion, which appears, typically, at the end of a report. A conclusion is a closing off; it answers the question "What does this report writer want me to believe or do?" Usually the writer asks the reader to make a decision, draw inferences, consider consequences, arrive at judgments, entertain recommendations for action. The writer goes beyond mere summation of points to some interpretation, drawing conclusions from the data in the text. It is useful to put conclusions into summaries as special final paragraphs. But summaries do not always bulk large in conclusions.

When to Write:

Abstracts and summaries are the last elements to be prepared for a report. If written before the report, they may represent only a rough prospectus that may not prove relevant. It is a fairly easy task to prepare both so that they will closely mirror the final version of the report. If the report is well organized, one can simply review it in sequence — noting major points, significant facts, important considerations, major conclusions — and make a list of key phrases or sentences. After all the relevant information is listed, it needs to be compressed, and the ideas need to be connected to form a coherent expression.

Length:

To express essential information in a report abstract, one needs about 200 carefully chosen words. (Some journals may impose shorter limits.) A summary may require 6 to 10% of the words or pages of the full report.

*Some types of reports preclude the use of an informative abstract — compilations of multiple presentations under one cover, bibliographies, handbooks, guidelines, mathematical solutions, one-page monthly progress reports, manuals, computer programs, for example.

EXAMPLES

These studies provide measurements of temperature dependence, injection level dependence, and modulation frequency response of cathodoluminescence in Te-rich CdTe:In for material with In concentrations ranging from $3 \times 10^{15}/\text{cm}^3$ to $1 \times 10^{18}/\text{cm}^3$. In lightly doped material, the 80-K luminescence shows sharp band-edge emission near 1.57 eV and a broad impurity-defect band near 1.4 eV. As temperature increases, the 1.4-eV band quenches out, leaving only the band-edge emission. In heavily doped material, the band-edge emission is absent and the 80-K luminescence shows only the 1.4-eV band. As the temperature increases from 80 to 300 K, the 1.4-eV band does not quench out but rather undergoes a complex evolution into a long tail on the band-edge emission that begins to appear at about 140 K. At a temperature of 200 K, where the luminescence of the heavily doped material consists of a broad but structured band about 0.2 eV in width, frequency response measurements indicate that band-to-band transitions contribute to the high-energy part of the broad luminescence, whereas the remainder of the band is the product of slower transitions. The frequency and temperature dependences suggest that the luminescence involves an impurity level that has merged with a band edge at an In concentration of $1 \times 10^{18}/\text{cm}^3$. This behavior indicates that the 1.4-eV luminescence in Te-rich CdTe:In results from a partially forbidden transition between conduction band and a deep acceptor level rather than from an intracenter type of transition.

To determine the mechanisms causing stress-corrosion cracking on uranium alloys, we investigated the kinetics of crack propagation and oxide-film growth for U-4.5% Nb at temperatures between 0° and 200°C in oxygen, water vapor, and oxygen/water vapor mixtures. We observed three regions of crack-velocity rate versus strain intensity in laboratory air. At low-stress intensities (but above an effective K_{ISCC} of $\text{MN}/\text{m}^{3/2}$) crack velocity varied approximately as K^{70} . In an intermediate-stress intensity region (region II) the crack velocity was dependent upon K^4 . In the high-stress intensity region we found mechanical overloading, with crack velocities varying approximately as K^{12} . Both cracking (region II) and oxidation rates were characterized by an activation energy of 29.3 kJ/mol. For stress-corrosion cracking, we found that although oxygen was the primary stress corrosive, a synergistic effect upon crack propagation rates occurred with oxygen/water vapor mixtures. Crack velocities were dependent upon the pressure of oxygen ($P_{O_2}^{1/3}$) and water vapor, whereas the oxidation rate was essentially independent of the pressure of these species. We considered stress-sorption and oxide-film-formation stress-corrosion-cracking mechanisms and reconciled them with the stress corrosion and oxidation data.

Issued by Technical Writing Division 3151. April 1977.

APPENDIX B

Report Format

THIS IS A DROPHEAD

This Is a Centerhead (CH)

Separated Sidehead (Sep Side, or SSH)

Run-In Sidehead (Run-In) -- These examples of headings, in order of decreasing importance are provided as examples of spacing, capitalization, and underlining. A drophead may be used only once in a report, for the title, or may be used for chapter headings in a very long report. It is typed on line 4 of 1/8 oversize masters, line 6 of 1/4 o.s. ones, and usually starts a right-hand page. Leave 4 vertical spaces between the drophead and the first centerhead, also 4 spaces between the last text in a section and a new centerhead.

If yours is an elite type (12 spaces per inch), it is preferable to use 1-1/2 line spacing on 1/8 o.s. masters (Form SA 1820-GM, S/N 697138). Second choice is to single space on 1:1 masters (SA 1820-GF, S/N 697150). For larger type such as pica (10 spaces per inch) or proportional spacing machines (PSM, the IBM Executive), first choice should be space and one-half on 1/4 o.s. masters (Form SA 1820-G, S/N 697144) and second choice single space on 1/8 o.s.

If the preferred 1-1/2 space format is adopted, other line-spacing rules are: 3 vertical spaces between centerhead and subsequent text or sep side; before any sep side - 3; after a sep side - 2 (but, before any run-in 2-1/2); and between paragraphs 2-1/2.

This sample is elite type, 1-1/2 space on 1/8 o.s., then reduced to 85% (button No. 2 on a Xerox 7000) which gives a close approximation of how the final printed copy will look. (Button No. 3 or 77% on the Xerox does the same for 1/4 o.s.)

In general, type on masters from dashed line to dashed line, but crowded tables and finely detailed illustrations may sometimes justify using the space from solid line to solid line. Odd-numbered pages are numbered at bottom right, even-numbered on the left. These numbers may sometimes indicate both section or chapter and the page within it, e.g., IV-15, especially if it is anticipated that revised pages will be published later.

Try to familiarize yourself with the commonest proofreader's marks, as for capitalize and lower case, abbreviate or spell out, "close up" vs insert space, etc.

APPENDIX C
Samples of Reference Formats

APPENDIX C

Samples of Reference Formats

Single Volume

Single Author

¹Conrad O. Jones, The Meaning of Waste Isolation (New York: Itinerant Press, 1969), p 28.

Two Authors

²Conrad O. Jones and Wendell W. Smith, Living with Nuclear Waste (San Francisco: The Opposition Press, 1977).

Three Authors

³Conrad O. Jones, Wendell W. Smith, and Larry S. Lopez, Nuclear Waste: Where Does It All Lead? (Albuquerque: The Small Press, 1978).

More than Three Authors

⁴Conrad O. Jones et al, Living or Existing: A Choice (Santa Fe: The Red Feather Press, 1979).

Author's Name Known but not Listed

⁵[Conrad O. Jones], The UFO Syndrome (Denver: Science Inc, 1978).

Editor's Name

⁶Conrad O. Jones, The Politics of Waste Isolation, ed Larry S. Lopez (Albuquerque: Southwestern Publishing Co, 1978).

Reader or Anthology: When referring to entire work

⁷Conrad O. Jones, ed, Ancient Southwestern Technology: A Reader (Phoenix: The Adobe Press, 1968).

Reader or Anthology: When referring to a selection

⁸Conrad O. Jones, "The Building of Hohokom Canals," An Anthology of Ancient Southwestern Technology, ed Larry S. Lopez (Phoenix: Irrigation Technology Press, 1968).

Author Unknown, General Editorship

⁹Is Waste Isolation the Answer? (New York: The Penguin Press, 1976).

Foreign Title

¹⁰ Ch'en Shich-ch'i, Ming-tai shou-kung-yeh ti yen-chiu [Studies on Government-Operated handicrafts during the Ming dynasty] (Hong-Kong: The Mandarin Press, 1978).

Subsequent Editions and Revisions

¹¹ Conrad O. Jones, Waste Isolation and the News Media (2nd ed; Hannibal, MO: The Mark Twain Press, 1979).

¹² Conrad O. Jones, Waste Isolation and the News Media (3rd ed rev; Hannibal, MO: The Mark Twain Press, 1979).

Place of Publication Unknown

¹³ Conrad O. Jones, On Being Sentient (np, 1968).

Notes

¹⁴ Conrad O. Jones, Waste Isolation: The Great Deceit (Chicago: The University of Chicago Press, 1984). The author, an instructor in semantics, has taken most of his information from news media accounts and has done no research on the hard facts of waste isolation.

Multiple-Volume Works

General Title

¹⁵ Conrad O. Jones, ed, Studies in Peaceful Uses of the Atom, III (Los Alamos, NM: The Isolation Press, 1978).

Individual Title for Each Volume

¹⁶ Conrad O. Jones, Operation Plowshare, vol III of Studies in Peaceful Uses of the Atom (Los Alamos, NM: The Isolation Press, 1978).

¹⁷ Conrad O. Jones, "Operation Plowshare," Studies in Peaceful Uses of the Atom, Vol III of Modern Sciences (Los Alamos, NM: The Isolation Press, 1979).

Work in a Series

¹⁸ Conrad O. Jones, Solar Power: An Alternative Fuel, 15 vols, Fuel Technology in the Twentieth Century, vol II (Santa Barbara, CA: The Desert Press, 1979).

Government Documents

Congressional: House (hearing)

¹⁹ US, Congress, House, Committee on Energy, Subcommittee on Alternative Sources, The Solar Thermal Facility in Barstow, California, Hearing, 92nd Cong, 2nd Sess, December 1978 (Washington: Government Printing Office, 1979).

Congressional: Senate (hearing)

²⁰ US, Congress, Senate, Committee on Immigration, Subcommittee on Illegal Aliens, The Problem of the Illegal Alien: Employment, Discrimination, Diplomacy, Hearing, 93rd Cong, 1st Sess, on SR 3201, to restrict immigration, April 1, 1976 (Washington: Government Printing Office, 1977).

Presidential Address to Congress

²¹US, President, 1976-80 (Carter), Halting Production of the Enhanced-Radiation Bomb, 92nd Cong, 2nd Sess, House, Document No 96 (Washington: Government Printing Office, 1978).

Symposium

²²DOE-NASA Symposium on Generating Solar-Electrical Power on Space Stations. Proceedings of a Symposium Held at the Los Alamos Scientific Laboratory, Los Alamos, NM, November 19-25, 1978, ed Carl N. Mora (Washington: Government Printing Office, 1979).

Congressional Record

²³US, Congressional Record, 92nd Cong, 2nd Sess (1978), CCIV, No 95, 11629-11700.

Personal Author

²⁴Conrad O. Jones, The Solar Tower Test Facility: A Prototype, US, Department of Energy Publication No 1078 (Washington: Government Printing Office, 1978).

Unpublished Sources

Dissertations and Theses

²⁵Conrad O. Jones, "The Isolation of Waste Isolationists" (PhD diss, University of New Mexico, 1978).

Scientific Paper

²⁶Conrad O. Jones, "Solar Power IS the Answer" (22nd annual meeting of the Scientists United for Sane Alternatives, Albuquerque, NM, December 1979).

Collections

²⁷Papers on Solar Energy (MSS in the University of New Mexico Zimmerman Library, Albuquerque). Hereafter this collection cited as PSE.

Manuscript Collection

²⁸Gerald W. Wallace Diaries, Special Collections at University of New Mexico (Microfilm copy, reels 1-67).

Interviews

²⁹Statement by C. J. Osgoode, solar energy engineer, personal interview, Barstow, CA, November 13, 1979.

Public Speech

³⁰Opinion expressed by Conrad O. Jones, engineer, in an address "Is Solar Power Cost Effective?" at the University of New Mexico, Albuquerque, December 31, 1978 (tape on file at the Sandia Laboratories Reference Library).

Letter (For alternative, See p. 38)

³¹Letter from Conrad O. Jones, Head of Engineering Division 0001 of Sandia Laboratories, Albuquerque, December 31, 1978.

Journals and Periodicals

Journals

- ³²Conrad O. Jones, "Tycoons and Solar Power," J Sol Power, 1:63, December 1978.

Journal with Series Designation

- ³³Conrad O. Jones, "A Prototype Solar-Powered Automobile," J Sol Eng 10(4):132 (1978).

Magazines (monthly)

- ³⁴Conrad O. Jones, "When Nuclear Waste Reaches Criticality," Newstime, January 1978, p 52.

Magazines (weekly); Column

- ³⁵Leisure in Modern Life, "The Politics of Hysteria: The Snail Darter vs Clean Energy," Weeknews, April 1, 1978, p 52.

Magazine, unsigned article

- ³⁶"Tampering with Genes," J Nucl Sci, December 1978, p 22.

Newspaper

- ³⁷The Tribune [Albuquerque], January 4, 1979, p 15, col 3.
³⁸The Albuquerque [New Mexico] Journal, January 4, 1979, p 15, col 3.
³⁹Editorial, The Roswell [New Mexico] Reporter, January 4, 1978, p B3.

APPENDIX D

Abbreviations of Periodical Titles

(Applied Science & Technology Index Copyright 1979 by the H. W. Wilson Company.
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5

6

3

4

ABBREVIATIONS OF PERIODICALS INDEXED

For full information see pages vii-xi

AAPG Bull—American Association of Petroleum Geologists Bulletin
 ACM Comm—ACM Communications
 ACM Trans Math Software—ACM Transactions on Mathematical Software
 AIAA J—AIAA Journal
 AIChE J—AIChE Journal
 ASHRAE J—ASHRAE Journal
 ASLE Trans—ASLE Transactions (American Society of Lubrication Engineers)
 ASTM J Test & Eval—ASTM Journal of Testing & Evaluation
 ASTM Stand N—ASTM Standardization News
 Acoust Soc Am J—Journal of the Acoustical Society of America
 Adhesives Age—Adhesives Age
 Aeronaut J—Aeronautical Journal
 Air Pollut Control Assn J—Journal of the Air Pollution Control Association
 Aircraft Eng—Aircraft Engineering
 Am Assn Pet Geologists Bull—American Association of Petroleum Geologists Bulletin
 Am Cer Soc Bull—Bulletin of the American Ceramic Society
 Am Cer Soc J—Journal of the American Ceramic Society
 Am Chem Soc J—Journal of the American Chemical Society
 Am City & County—American City and County
 Am Concrete Inst J—Journal of the American Concrete Institute
 Am Dyestuff Rep—American Dyestuff Reporter
 Am Ind Hygiene Assn J—American Industrial Hygiene Association Journal
 Am J Phys—American Journal of Physics
 Am J Sci—American Journal of Science
 Am Mach—American Machinist
 Am Math M—American Mathematical Monthly
 Am Meteorol Soc Bull—American Meteorological Society Bulletin
 Am Metric J—American Metric Journal
 Am Mineralogist—American Mineralogist Journal of the Mineralogical Society of America
 Am Oil Chem Soc J—Journal of the American Oil Chemists' Society
 Am Scientist—American Scientist
 Am Soc C E Proc—Proceedings of the American Society of Civil Engineers
 CO—Construction Division; EE—Environmental Engineering; EI—Engineering, Issue; EM—Engineering Mechanics; GT—Geotechnical Engineering; HY—Hydraulics Division; IR—Irrigation & Drainage; PO—Power Division; ST—Structural Division; SU—Surveying & Mapping; TC—Technical Councils; TE—Transportation Engineering; UP—Urban Planning; WR—Water Resources Planning & Management Division; WW—Waterway Port Coastal and Ocean Division
 Am Water Works Assn J—Journal American Water Works Association
 Anal Chem—Analytical Chemistry
 App Math & Mech—Applied Mathematics and Mechanics
 App Opt—Applied Optics
 App Phys—Applied Physics
 Archit Rec—Architectural Record
 Assn for Comp Mach J—Journal of the Association for Computing Machinery
 Astronaut & Aeronaut—Astronautics & Aeronautics
 Atmos Environ—Atmospheric Environment
 Audio—Audio
 Audio Eng Soc J—Journal of the Audio Engineering Society
 Automob Q—Automobile Quarterly
 Automot Eng—Automotive Engineering
 Automot Ind—Automotive Industries
 Aviation W—Aviation Week & Space Technology

Bell Lab Rec—Bell Laboratories Record
 Bell Syst Tech J—Bell System Technical Journal
 Bldg Syst Design—Building Systems Design
 Bus/Comm Aviation—Business/Commercial Aviation

CIM Bull—CIM Bulletin (Canadian Mining and Metallurgical Bulletin)
 Can Chem Process—Canadian Chemical Processing
 Can J Chem Eng—Canadian Journal of Chemical Engineering
 Cer Ind—Ceramic Industry
 Chem & Eng N—Chemical & Engineering News
 Chem & Ind—Chemistry and Industry
 Chem Eng—Chemical Engineering
 Chem Eng Prog—Chemical Engineering Progress
 Chem Tech—Chemical Technology
 Civil Eng—Civil Engineering—ASCE
 Coal Age—Coal Age
 Combustion—Combustion
 Comp Design—Computer Design
 Comp J—The Computer Journal
 Comp Surv—Computing Surveys
 Computer—Computer
 Constr Contract—Construction Contracting
 Constr Methods—Construction Methods and Equipment
 Control Eng—Control Engineering
 Corrosion—Corrosion
 Corrosion Sci—Corrosion Science
 Cosmet & Toilettries—Cosmetics and Toilettries
 Crit R Environ Control—Critical Reviews in Environmental Control
 Cryogenics—Cryogenics
 Cutting Tool Eng—Cutting Tool Engineering

Data Process—Data Processing
 Design N—Design News

EDN—EDN
 Econ Geol—Economic Geology and the Bulletin of the Society of Economic Geologists
 Elastomerics—Elastomerics
 Elect Comm—Electrical Communication
 Elect Constr & Maint—Electrical Construction and Maintenance
 Elect World—Electrical World
 Electrochem Soc J—Journal of the Electrochemical Society
 Electron Design—Electronic Design
 Electron Eng—Electronic Engineering
 Electron & Power—Electronics & Power
 Electronics—Electronics
 Energy Convers—Energy Conversion
 Energy Sources—Energy Sources
 Energy Syst & Pol—Energy Systems & Policy
 Eng & Min J—Engineering and Mining Journal
 Eng J—Engineering Journal
 Eng J (U.S.)—Engineering Journal (U.S.)
 Eng N—Engineering News-Record
 Engineer—Engineer
 Engineering—Engineering
 Environ Conser—Environmental Conservation
 Environ Sci & Tech—Environmental Science & Technology
 Exper Mech—Experimental Mechanics

Fire J—Fire Journal
 Fire Tech—Fire Technology
 Food Eng—Food Engineering
 Food Tech—Food Technology
 Foundry Mgt & Tech—Foundry Management & Technology

Gas Turbine Int—Gas Turbine International
 Geol Soc Bull—Bulletin of the Geological Society of America
 Geology—Geology
 Geophysics—Geophysics
 Glass Ind—Glass Industry

Heating-Piping—Heating, Piping & Air Conditioning
 Highw & Heavy Constr—Highway & Heavy Construction
 Human Factors—Human Factors
 Hydraul & Pneum—Hydraulics & Pneumatics
 Hydrocarbon Process—Hydrocarbon Processing

IBM J Res & Devel—IBM Journal of Research and Development
 IBM Syst J—IBM Systems Journal
 IEEE Proc—Proceedings of the IEEE
 IEEE Spectrum—IEEE Spectrum
 IEEE Trans Comm—IEEE Transactions on Communications
 IEEE Trans Ind Appl—IEEE Transactions on Industry Applications
 IEEE Trans Power Appar & Syst—IEEE Transactions on Power Apparatus and Systems
 ISA Trans—ISA Transactions
 ITE J—ITE Journal
 Illum Eng Soc J—Journal of the Illuminating Engineering Society
 Ind & Eng Chem Fundamentals—Industrial and Engineering Chemistry Fundamentals
 Ind & Eng Chem Process Design & Devel—Industrial and Engineering Chemistry Process Design and Development
 Ind & Eng Chem Product Res & Devel—Industrial and Engineering Chemistry Product Research and Development
 Ind Design—Industrial Design
 Ind Eng—Industrial Engineering
 Ind Finish—Industrial Finishing
 Ind Phot—Industrial Photography
 Ind Wastes—Industrial Wastes
 Inst E E Proc—Proceedings of the Institution of Electrical Engineers
 Inst Fuel J—Institute of Fuel Journal
 Inst Mech Eng Proc—Proceedings of the Institution of Mechanical Engineers
 Instr & Control Syst—Instruments and Control Systems
 Instrum Tech—Instrumentation Technology
 Int J Powder Metall & Powder Tech—International Journal of Powder Metallurgy & Powder Technology
 Iron Age—Iron Age
 Iron & Steel Eng—Iron and Steel Engineering
 Ironmaking & Steelmaking—Ironmaking & Steelmaking

J Agri & Food Chem—Journal of Agricultural & Food Chemistry
 J Aircraft—Journal of Aircraft
 J App Mech—Journal of Applied Mechanics
 J App Meteorol—Journal of Applied Meteorology
 J App Phys—Journal of Applied Physics
 J Atmos Sci—Journal of Atmospheric Sciences
 J Chem & Eng Data—Journal of Chemical & Engineering Data
 J Combust Toxicol—Journal of Combustion Toxicology
 J Consumer Prod Flammab—Journal of Consumer Product Flammability
 J Dyn Syst Meas & Control—Journal of Dynamic Systems, Measurement & Control
 J Eng Ind—Journal of Engineering for Industry
 J Eng Materials & Tech—Journal of Engineering Materials and Technology
 J Eng Power—Journal of Engineering for Power
 J Environ Health—Journal of Environmental Health
 J Environ Sci—Journal of Environmental Sciences
 J Environ Syst—Journal of Environmental Systems
 J Fire & Flammab—Journal of Fire & Flammability
 J Fire Retard Chem—Journal of Fire Retardant Chemistry
 J Fluids Eng—Journal of Fluids Engineering
 J Food Sci—Journal of Food Science

J Geol—Journal of Geology
 J Guidance & Control—Journal of Guidance and Control
 J Hazard Materials—Journal of Hazardous Materials
 J Heat Transfer—Journal of Heat Transfer
 J Lubr Tech—Journal of Lubrication Technology
 J Metals—Journal of Metals
 J Pet Tech—Journal of Petroleum Technology
 J Phys & Chem Ref Data—Journal of Physical and Chemical Reference Data
 J Pressure Vessel Tech—Journal of Pressure Vessel Technology
 J Quality Tech—Journal of Quality Technology
 J Res—Journal of Research
 J Spacecraft & Rockets—Journal of Spacecraft and Rockets

Light Metal Age—Light Metal Age
 Lighting Design & Appl—Lighting Design & Application
 Lubr Eng—Lubrication Engineering

M Weather R—Monthly Weather Review
 Mach Design—Machine Design
 Manuf Eng—Manufacturing Engineering
 Marine Eng/Log—Marine Engineering/Log
 Marine Geotech—Marine Geotechnology
 Marine Tech—Marine Technology
 Marine Tech Soc J—Marine Technology Society Journal
 Material Handl Eng—Material Handling Engineering
 Materials Eng—Materials Engineering
 Materials Eval—Materials Evaluation
 Materials Performance—Materials Performance
 Math Mag—Mathematics Magazine
 Math of Comput—Mathematics of Computation
 Math Sci—Mathematical Sciences
 Mech Eng—Mechanical Engineering
 Metal Finish—Metal Finishing
 Metal Prog—Metal Progress
 Metall & Metal Forming—Metallurgia and Metal Forming
 Metallurgia—Metallurgia
 Metals & Materials—Metals and Materials
 Metals Tech—Metals Technology
 Microwave J—Microwave Journal
 Microwaves—Microwaves
 Min Cong J—Mining Congress Journal
 Min Eng—Mining Engineering
 Mod Cast—Modern Casting
 Mod Mach Shop—Modern Machine Shop
 Mod Materials Handl—Modern Materials Handling
 Mod Metals—Modern Metals
 Mod Pkg—Modern Packaging
 Mod Plastics—Modern Plastics
 Mod Textiles—Modern Textiles

N Scientist—New Scientist
 Naval Eng J—Naval Engineers Journal
 Noise Control Eng—Noise Control Engineering
 Nucl Eng Int—Nuclear Engineering International
 Nucl Ind—Nuclear Industry
 Nucl N—Nuclear News
 Nucl Safety—Nuclear Safety
 Nucl Tech—Nuclear Technology
 Nutr Today—Nutrition Today

Ocean Eng—Ocean Engineering
 Oceanus—Oceanus
 Offshore—Offshore
 Oil & Gas J—Oil & Gas Journal
 Opt Eng—Optical Engineering
 Opt Soc Am J—Journal of the Optical Society America

PE-Prof Eng—PE-Professional Engineer
 PIMA—PIMA Magazine
 Paper Ind—Paper Industry
 Pet Eng Int—Petroleum Engineer International
 Phys & Chem—Physics and Chemistry
 Phys Today—Physics Today
 Pipe Line Ind—Pipe Line Industry

Pipeline & Gas J—Pipeline & Gas Journal
Pkg Eng—Package Engineering
Plant Eng—Plant Engineering
Plastics Design & Process—Plastics Design & Processing
Plastics Eng—Plastics Engineering
Plastics Tech—Plastics Technology
Plastics World—Plastics World
Plating & Surface Finish—Plating and Surface Finishing
Pollut Eng—Pollution Engineering
Polym Eng & Sci—Polymer Engineering Science
Power—Power
Power Eng—Power Engineering
Process Eng—Process Engineering
Product Eng—Product Engineering
Production Eng—Production Engineering
Prof Safety—Professional Safety
Pub Roads—Public Roads
Pub Works—Public Works

Q App Math—Quarterly of Applied Mathematics
QST—QST
Quality Prog—Quality Progress

RCA R—RCA Review
R Sci Instr—Review of Scientific Instruments
Radio & Electron Eng—Radio and Electronic Engineer
Radio-Electron—Radio-Electronics
Radio Sci—Radio Science
Res/Devel—Research/Development
Rock Prod—Rock Products
Rubber Chem & Tech—Rubber Chemistry and Technology

SIAM J App Math—SIAM Journal on Applied Mathematics
SIAM J Control & Optim—SIAM Journal on Control and Optimization
SIAM R—SIAM Review
SMPTE J—Journal of the Society of Motion Picture and Television Engineers
Sci Am—Scientific American
Sci Instr—Scientific Instruments
Science—Science
Seismolog Soc Am Bull—Seismological Society of America Bulletin

Soap/Cosmet/Chem Spec—Soap/Cosmetics/Chemical Specialties
Soc Dyers & Col J—Journal of the Society of Dyers and Colourists
Soc Pet Eng J—Society of Petroleum Engineers Journal
Software—Software: Practice and Experience
Solar Energy—Solar Energy
Solid-State Electron—Solid-State Electronics
Solid Wastes Mgt/Refuse Removal J—Solid Wastes Management/Refuse Removal Journal
Sound & Vib—Sound & Vibration
Specif Eng—Specifying Engineer
Studies App Math—Studies in Applied Mathematics
Surv & Mapp—Surveying & Mapping

Tappl—Tappi
Tech R—Technology Review
Textile Ind—Textile Industries
Textile Res J—Textile Research Journal
Textile World—Textile World
Tooling & Prod—Tooling & Production
Traffic Eng—Traffic Engineering
Traffic Q—Traffic Quarterly
Transp Eng—Transportation Engineering
Transp Res—Transportation Research
Transp Sci—Transportation Science
Turbomach Int—Turbomachinery International

Ultrasonics—Ultrasonics

Vacuum—Vacuum

WPCF J—Journal Water Pollution Control Federation
Water & Pollut Control—Water & Pollution Control
Water & Sewage Works—Water & Sewage Works
Water & Wastes Eng—Water and Wastes Engineering
Water Res—Water Research
Weld Design & Fabr—Welding Design & Fabrication
Weld J—Welding Journal
Wire J—Wire Journal
Wireless World—Wireless World
World Oil—World Oil

APPENDIX E

Letter Requesting Copyright Release

November 27, 1978

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Boston, MA 02108

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R. F. Abbey, Jr. "Concentration Measurements
Downwind of Buildings: Previous and Current
Experiments." Figure 1.

Journal of Applied Meteorology Vol. 14: 1080-94, 1975
"Studies of Atmospheric Diffusion from a
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APPENDIX F

How Engineers and Scientists Write

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Why Engineers and Scientists Write As They Do— Twelve Characteristics of Their Prose

GEORGE E. SCHINDLER, JR., MEMBER, IEEE

Abstract—The writing of scientists and engineers is severely criticized, but the critics seldom dig into the reasons for its supposed weaknesses and faults. By analyzing technical writing, however, we find that many of the "faults" are justifiable if not carried to extremes, and if not used inappropriately when writing for nontechnical audiences.

THIS PAPER is an attempt to shed some light on the structure of the prose of scientists and engineers. It assumes that we are unable to judge the quality of professional writing in science and engineering until we can first define what such writing is.

We begin by performing what physicists call a thought experiment. We take a representative sample of good, contemporary, informative prose—some selections, for instance, from the works of our better magazine writers. Alongside it we place another representative sample of informative prose, but this time consisting of papers from our best science and engineering journals. If we then compare these two samples closely, what differences might we find? Assume that we ignore all superficial differences, such as the fact that the vocabulary of the nonscientist-writer might refer to national politics, whereas the scientist-writer's vocabulary might refer to quantum mechanics, would we find any significant variations in prose styles?

I think such an analysis would show that the styles are very different. What follows is an attempt to illustrate these differences and to explain some of the reasons for their existence.

Before getting down to specifics, however, a few more words of introduction may be in order. In the title of this paper I have referred to twelve characteristics of technical writing, rather than twelve faults or twelve virtues, because, insofar as possible, I want to avoid value judgments. With some exceptions that should be apparent, I merely wish to point out elements of technical prose that differ from the generality of contemporary prose in other fields, leaving the reader to judge whether these differences are good or bad. Although most of the twelve characteristics discussed below are usually interpreted as "faults," I do not believe them to be necessarily so.

I. LONG SENTENCES

A comparison of sentence lengths quickly shows that the average technical sentence is significantly longer than

the average English sentence being written today. Perhaps enough has been said by others about the tendency toward long sentences in technical writing; however, two points may be worth mentioning.

First, sentences tend to become long because of the technical writer's desire to be factually accurate. When making a statement, with a capital letter at the beginning and a period at the end, he tends to feel that any qualifications—the modifiers that prevent possible misinterpretations—must be included within the bounds of that same sentence. There is a certain finality about the convention of punctuating with a capital letter and a period. The resulting sentence can be pulled out of context and, if someone misinterprets the meaning, or if someone merely points out that a wrong meaning is possible, the writer is quite understandably embarrassed.

But there is no real reason that all or even most qualifications must be included in a single sentence. A writer can afford to state at least some qualifications in separate sentences, and he can do so with no loss of technical accuracy. The style is better, and if an occasional isolated sentence could theoretically be misread, the paragraph in which it occurs can be unquestionably clear.

The second point is that long sentences are normally not greatly improved by attempts to repunctuate them into two, three, or more sentences. Purely mechanical attempts at repunctuation will often merely produce choppy, disconnected thought fragments. Problems of sentence length are not that easily solved; usually they will be found to lie much deeper within the stylistic structure of the paper.

II. PASSIVE VOICE

The very frequent use of passive verbs is such an obvious feature of the writing of scientists and engineers that it needs little detailing. The characteristic is extensively analyzed in virtually every discussion of technical writing. It therefore seems necessary to mention only a few peripheral matters and to stress the reason passive verbs occur.

It is easy to become militantly opposed to the passive voice and to insist on a wholesale substitution of the active. Yet in much technical writing there are only certain contexts in which active verbs can be used.

In formal or semiformal prose, writers use the passive voice as a convenient way to avoid personal pronouns. Specifically, the passive verb ("An amplifier *was designed*") avoids the seemingly boastful use of the active verb

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with personal pronouns or nouns ("I designed an amplifier; We designed . . . ; The research group designed . . ."; and so on). Since the alternatives here are largely a matter of the writer's individual taste, the most one can say is that many readers prefer a personalized approach, but that some groups of readers—possibly the members of science and engineering organizations, for example—may find this type of active voice inappropriate.

Avoiding such personal statements of "Who did what," however, justifies the passive voice in only this one context. Elsewhere there may be no question of personal credit to the author or his associates. The author may be writing, not about his own contribution, but about the actions of someone else. By force of habit, though, he often continues to use the passive voice ("The output level is determined") when he could just as well introduce an agent to make the sentence active and more vivid ("An operator determines the output level").

Also by force of habit, an author will sometimes use the passive voice when there is no question at all of a human agent:

In an earlier report, a new equipment design was outlined, and a new method of fabrication was discussed.

Since an agent already exists in the sentence (the earlier report), we can easily rewrite it in the active voice:

An earlier report outlined a new equipment design and described a new method of fabrication.

Passive verbs, in many instances, are quite defensible. They avoid an attitude of boastfulness, and of course they are an absolute necessity in many sentences when there is no agent for an action or when the agent is unknown. The mistake some writers make is to extend their use of the passive until it almost completely pervades their prose, which, as a consequence, becomes lifeless and dull.

Technical writers usually cannot write highly personalized accounts of their work. But they can use the active voice in that area of writing where active verbs do not require introducing personal pronouns.

III. NOUNS INSTEAD OF VERBS

When a writer states, "The theory is in agreement with the facts," he has, consciously or otherwise, chosen to use a noun in place of a verb. He could have deleted the noun *agreement* and substituted the verb *agrees*: "The theory agrees with the facts."

As another example, a writer states that "A motor is capable of efficient control of the actuating lever." Here the noun *control* can easily be converted to the verb: "A motor can efficiently control the actuating lever." And compare the noun in "Testing is done only at the main sites" with the verb in "Amplifiers are tested only at the main sites." And again, the noun in "At this point the officer makes a decision to launch the missile" could have been a verb in "At this point the officer decides to launch the missile."

What are we to conclude from the noun forms in these sentences, and from the high concentration of their counterparts seen in almost any sample of technical writing? It must be that nouns—since they are customarily the words that state designations, measurements, dimensions, and numbers—seem to be associated with, and thus mistaken for, facts, upon which good science and engineering depend. To some writers, the *fact* of testing must seem more worthy of emphasis than the *act* of testing. Perhaps this feeling derives from the writer's knowledge that he, as the designer, invented or developed the testing—that is, the procedure for testing the amplifier—whereas the actual job of testing concerns not himself but the person operating the system.

As a further example, consider the noun *amplification* in the following sentence:

Amplification of the output voltages is provided by a circuit in the cabinet.

The writer could have used the verb *amplifies*:

A circuit in the cabinet amplifies the output voltages.

Perhaps, however, he was thinking that he, as the person who worked out this arrangement, was the one who *provided amplification*. That is, he was responsible for the existence of the amplification for the particular system. Consequently, the noun may express this thought better than the verb.

If this is the explanation of the strong preference for noun forms in technical writing, it is a perfectly legitimate one. It should be obvious, however, that like many others of these twelve characteristics, it can easily become a bad habit. For special emphasis, the good writer will occasionally use a noun form where a verb would otherwise be more natural. But this is quite different from saying that the practice remains a virtue if applied universally. After all, the verb forms do, in general, tend to be clearer and more interesting to read.

IV. Which INSTEAD OF That

Because scientists and engineers feel obliged to qualify their statements extensively, the proportion of subordinate clauses in technical writing is much higher than average. And for the purpose of inserting such clauses into sentences, the relative pronoun *that* in certain constructions has been almost completely replaced by *which*.

Part of the explanation for this may be the different functions of the two words in some sentences. Note that in the following, for example, it is impossible to change *that* to *which*: "They knew *that* the machine would not work." Here the clause is not subordinate to the rest of the sentence, but serves instead as the object of the verb *knew*. Such instances demand *that*.

In many cases, however, the writer has an option. The reason this option is not exercised more frequently is not entirely clear. Perhaps some writers feel it is more logical to restrict *that* to positions where there is no alternative,

and to use *which* in all other cases.

There are two rather unfortunate consequences of the heavy use of *which*. Because technical writing must be rather heavily qualified, the result is often a repetitive dullness in the frequent recurrence of *which* clauses. Shorter sentences with fewer qualifiers help, but when subordinate clauses must be used, an occasional shift to *that* tends to relieve monotony.

The second consequence is that the traditional distinction between the "nonrestrictive" *which* clause and the "restrictive" *that* clause is almost entirely abandoned. This rule may be only a minor elegance of style, but it helps to increase sentence variety and thus makes for more interesting reading.

V. LACK OF PUNCTUATION

There are some instances, as in the use of a comma before the *and* in a series, where scientists and engineers tend to be conservative and to use punctuation in situations where nowadays it is apt to be omitted. In general, however, technical prose is grossly underpunctuated.

For reasons discussed above, such prose tends to be heavily qualified. Many of the subordinate, qualifying phrases and clauses tend to be rather lengthy. The common practice is to place commas around most long, subordinate constructions. But if this rule were followed conscientiously in technical writing, many sentences would become terribly chopped up. A rather long sentence might have a half dozen commas or more, not to mention a semicolon or two. Reading would be impaired by the many interruptions.

Sensing this, technical writers tend to omit commas around subordinate qualifiers (and commas separating multiple adjectives before a noun) unless they are very necessary to an understanding of the sentence.

Sentence length and punctuation are thus seen to be interrelated. At first glance, much technical prose seems curiously devoid of necessary punctuation. But, paradoxically, inserting the missing punctuation sometimes makes the sentences worse. To solve the problem one must usually undertake a fundamental revision of the sentences and their contexts. It is true that popular writers today use less punctuation than their counterparts of 50 or 100 years ago. But this merely seems to be a reflection of the fact that they also write shorter sentences. A short sentence containing one short subordinate phrase can usually be grasped easily without need for the pauses created by commas.

VI. KEY IDEA UNDERPLAYED

An engineer writes that a unit of equipment is installed "on a shock-mounted basis." It is clear from the context that the shock mounting is an important factor in his design. Yet the words *shock-mounted* appear in an adjective form modifying the noun *basis*. Why is this important idea expressed with a relatively unimportant part of speech?

If a writer wants to emphasize a point, he should reflect

its weight with grammatical weight. By and large, nouns and active verbs convey ideas most clearly and emphatically, especially so if they occupy the important grammatical positions in the sentence—the subject, main verb, and object. A noun serving as the object of a preposition comes through to the reader with less force than a noun serving as the subject. A verb in its participle form as a modifier is much less emphatic than as the main verb of action.

It is surprising in analyzing technical writing to discover how many important concepts are obscured by being phrased in grammatically unimportant forms. There should be at least a rough correspondence between the two. A crucial idea should be very visible grammatically.

VII. INANIMATE ACTION AVOIDED

In a previous example we revised two passive verbs into the active form:

An earlier report *outlined* a new equipment design and *described* a new method of fabrication.

Similarly, we changed "A motor is capable of efficient control" to "A motor can efficiently control." The general preference for the passive voice partially explains the fact that these active forms are not used more often. But there is another reason. The active verbs are resisted also because they sometimes seem to endow inanimate objects with human attributes. Thus we occasionally see a rule in style manuals that inanimate objects should not show possession or seem to perform human actions. One should not write "the missile's nose cone," but "the missile nose cone" or "the nose cone of the missile." An inanimate missile can't *possess* a nose cone.

Again, some writers hold that the "earlier report" could not *outline* or *describe*; only a human being could do that. The equipment *was described* in the report, such writers claim; or, if personal pronouns are acceptable, *I described* or *we described* the equipment in the report. Similarly, a motor cannot *control*. One might say that only humans can *agree*, so that it is illogical to write that "The theory *agrees* with the facts."

This point of view has a sort of apparent good sense. Unfortunately, however, either the principle is false or most professional writers are in error. Personification of the inanimate is a very useful stylistic technique. Even though it is typically overdone by those who write exaggerated accounts of scientific developments, it still can be used unobtrusively to give writing a clarity, conciseness, and emphasis that are otherwise very difficult to achieve.

VIII. MEANINGLESS WORDS

Technical writing has no monopoly on pleonasm—more words than are necessary to express a thought. It is only necessary to illustrate a few ways in which excess words occur, and to point out those aspects of the problem that have a particular relevance to technical writing.

We have referred to the phrasing that a unit "is installed

on a shock-mounted basis." This can easily be rewritten to read that the unit "is installed on shock mounts"—five words instead of seven. Another rewritten phrase, "can efficiently control," instead of "is capable of efficient control," substitutes three words for five. The question is whether the extra words have any real meaning, especially the frequently used nouns, *case* and *basis*.

A few similar words often used pleonastically are *means*, *manner*, *reference*, *standpoint*, and *connection*. Consider, for example:

The pressure is varied by mechanical *means* (is varied mechanically), and

The motor can be used in *connection* with a regulator (used with a regulator).

In technical writing, there seems to be a strong force at work that tends to produce this type of inflated, wordy prose. Much of it is mere carelessness, of course. Still, such usage may indicate that with scientific subjects, writers seem to want to deal with tangible, nameable "things." It may be that the words "varied mechanically" do not quite convey the complete meaning of "varied by mechanical means." The author may have had in mind an actual mechanism that varies the pressure.

Another author might write: "Provision is made for the regulation of the output." Noting the wordiness, we could suggest simply: "The output is regulated." But again, the author may have had in mind the *act* of providing—that is, actually designing or installing a device to regulate the output. It may seem to him that his use of the noun *provision* is the only way to state the idea and give it sufficient emphasis. What appears to be bad writing may actually be so, but we cannot hope to improve it until we understand the reasons for its existence.

IX. MULTIPLE ADJECTIVES

As with long sentences and the passive voice, the occurrence of multiple adjectives before nouns in technical writing is so obvious that there is no need to elaborate upon its existence. One writer refers to a "low-capacity central location control point," another to "below threshold nonaudible microphonics," and a third to a system that operates through a "mobile maintenance service base station system."

Often it takes considerable mental agility to grasp the meaning of such long, complicated expressions. As suggested earlier, punctuation may help, but frequently the only way to transform the idea into good English is to rewrite the sentence.

There are at least two reasons why multiple adjectives occur with high frequency in technical writing. First, such usage is another form of qualification intended to result in an approach to complete accuracy. The control point is not just any control point; it is a *central location* control point. It is not just any central location control point; it is

a *low-capacity* central location control point. The author tries very hard to be as complete, specific, and unambiguous as possible. In this way he hopes to eliminate all misunderstanding. That he frequently does so by sacrificing ease of reading is, in science and engineering, of secondary importance.

Second, multiple adjectives are used because they are actually a form of "shorthand" which sometimes results in a desirable conciseness. Assume a specialist reader who is thoroughly familiar with this type of control, who knows the logic of having a central location for the control point, and who is acquainted with the distinction between low-capacity and high-capacity systems of this type. He may then be able to read the above five-adjective combination as rapidly, and with as much comprehension, as we can read ordinary colloquial prose. Also, the trained reader sometimes recognizes such expressions as official titles, as they appear in reports or on nameplates attached to equipment.

One way to avoid multiple adjectives is to devote an entire sentence to the ideas they express: "The system at the base station is used for mobile service of the maintenance type." This version uses fifteen words instead of the original six. Besides, it may be misleading; a separate sentence may give undue emphasis to relatively unimportant ideas.

At the risk of needless repetition, it should be pointed out that we see here another phenomenon of technical writing that is not a fault per se, because there are legitimate, understandable reasons for its occurrence. It becomes a fault only for specific groups of readers, or only when it becomes a bad habit and is indulged in indiscriminately. There are forces at work in technical writing that demand multiple adjectives more frequently than in other types of writing. But they should be used sparingly when the nonspecialist is a reader, and of course they should never be used thoughtlessly.

X. LATIN INSTEAD OF ANGLO-SAXON

The Latinized vocabulary is another fairly obvious feature of technical writing. In an earlier example the word *capable*, derived from the Latin, was used instead of the Anglo-Saxon *can*: the motor "is *capable* of efficient control" instead of "*can* efficiently control" the actuating lever.

In technical writing, this characteristic frequently appears in the familiar instance of *approximately* instead of the Anglo-Saxon *about*: "The unit weighs *approximately* (about) eight pounds." Perhaps a less obvious instance is seen in the following wording: "This unit has no *provision* for reducing the output power." Here the Latin-derived *provision* might be replaced by the Anglo-Saxon way: "This unit has no way of reducing the output power." The author, who might have written that "The amplifier looks like the transmitter," actually wrote: "The amplifier is visually identical with the transmitter."

In the following sentence, the four italic words are Latin forms:

It would have been *difficult* to *accomplish* a *similar* *objective* with the older techniques.

In theory, all could be converted to their corresponding Anglo-Saxon words:

It would have been *hard* to *do* the *same* *thing* with the older techniques.

The conventional approach to a Latinized vocabulary is to condemn it as pompous, and there is no need to dwell upon such criticism here. The technical writer, as all who write, should be sensitive to the impression such words may leave with the reader.

One should also be sensitive, however, to the well-known fact that there are no exact synonyms. One of the great advantages of the English language is that it has many alternative words, drawn from many sources, to express fine shades of meaning. The words *approximately* and *about* come as close to being exact synonyms as anyone could expect, but the same cannot be said for some of the other choices in the examples. The meaning of *similar* is not that of *same*, and *no provision for* can be interpreted quite differently from *no way of*.

This is not to defend the original sentences. They do indeed have about them a pompous air. But it is no solution to suggest a wholesale deletion of such words and a substitution of "the good, old-fashioned Anglo-Saxon words of one syllable." Writers should try very hard to find the shorter word; but if it does not express the meaning, it should not be used.

In this matter, one other point is often overlooked. Sometimes the question is not so much one of meaning as of tone. Anglo-Saxon words are often quite colloquial in their connotations, and since technical writing is usually expected to be rather formal, certain usages may be inappropriate. A question of integrity is also involved: if the writer is himself informal in his manner, he should strive for at least a somewhat more informal writing style; if he tends to be formal, his style should correspond.

XI. INAPPLICABLE LOGIC

In all writing, not only technical, there is a tendency to look for "logical" explanations of grammar and diction. Because of the particular emphasis on precision in the sciences, however, this tendency may be stronger in technical writing than it is elsewhere.

To illustrate what is meant by this approach to correctness in writing, consider the following "logical" rules.

—Do not use "dc current" or "dc voltage," since the abbreviation includes the word *current*. The term "dc current" is therefore redundant, and "dc voltage" is nonsensical.

—Do not use the term "preventative." It is incorrect because it is illogical to insert the *as* when adding the suffix *ive* to *prevent*.

—Do not use the expression "ten times faster." Since "one times faster" really means "twice as fast," and so on, "ten times faster" really means "eleven times as fast."

—Do not use a plural verb with *none*, since the real meaning of this word is "no one."

—Do not insert an adverb or any other construction into a compound verb like "had been designed." These words form a unit in themselves and should not be separated, as in "had *already* been designed."

Similarly, as explained above, it is "illogical" to let inanimate objects perform animate actions.

The "logic" of such statements is apparent, and it should also be apparent that some of these rules are good advice. The word *preventative* should in fact be avoided, and in many sentences it is just as easy to spell out *direct current* as to write "dc current."

The trouble is that, although the advice may sometimes be good, this type of logic does not determine "correctness." Logically, the words *adaptation*, *presentation*, *orientation*, *representative*, and *commentator* are as objectionable as *preventative*. The use of a singular noun *watt* in a plural expression such as *ten-watt generator* appears, superficially, to be ridiculous.

One is reminded of the many expressions formerly thought to be logically unsound, which are now legitimate and useful parts of our vocabulary. The phrase "*under* the circumstances" was once regarded as an error, since we could hardly expect the idea of *circum-* or "around" to sit well with the idea of "*under*." The seemingly inoffensive word *reliable* was formerly a cause for alarm, since if any such adjective was to be formed from the intransitive verb *rely*, it was logically supposed to be "rely-upon-able."

The point is not that a writer should use every new phrase, meaning, or coinage the moment it is invented. Many of them are soon cast aside as fulfilling no real need in the language. A writer, for example, should cross out *wide bandwidth* and try to find a better, more logical expression. But logic alone does not determine whether a term will last, except the logic that if enough people use it meaningfully, it will survive and in time become acceptable usage.

XII. VERBOSITY AND CONCISENESS

It should be apparent from several of the above examples that, paradoxically, technical writing tends to be verbose and concise at the same time. We have alluded to the verbosity of the passive voice, of the heavy use of nouns, and of the Latinisms, and we have pointed to several words used pleonastically. Yet we have also pointed out that multiple adjectives are a form of concise, science shorthand.

The conciseness of much technical prose can be illustrated by a simple experiment. Select a paragraph from a highly technical article, even if it seems a little wordy, and challenge someone to rewrite it in terms that would be more broadly comprehensible. The interesting fact is that any rewrite for a nonspecialist reading audience will, on the average, demand more words. For a popular, "man-in-the-street" presentation, the complete meaning of even a brief paragraph might easily require an entire book. It is quite apparent that, despite occasional wordiness, much technical prose is really an extreme form of shorthand developed by specialists for communicating with other specialists.

The paradox, therefore, is more apparent than real. The engineer or scientist feels forced into verbosity by the demands for completeness and accuracy; yet within this requirement he is expected to use the shorthand of science. This is true of good as well as of bad technical writers. The good writer conveys his meaning efficiently. He does not let his sentences get overly long, but he still qualifies his ideas enough to avoid misleading fellow members of his profession.

However, when his writing—even at its very best—is read by a person who is not a member of his particular specialized group, it seems unintelligible. Such writing is not necessarily poor merely because it is so judged by people for whom it was not intended. It becomes poor when the writer intends to write for a broader audience, but does not depart from the habits that have served him well within his field of science or engineering. Long sentences, heavy qualifications, "shorthand" terms, excess verbiage, Latinized words, and passive constructions become insur-

perable obstacles to the reader. The prose may possibly be very good for the specialist, but the general reader makes no allowances. He is usually not required to read it, so if he cannot read it easily, he simply quits.

Of course such writing is frequently inadequate even for communication within a single profession. The writer quite properly reacts to the pressure toward conformity with the writing practices of his group, but he errs if he succumbs abjectly. He needs to qualify and to define exactly, but the danger is that his sentences can become so impossibly larded with subordinate phrases and clauses that even his close associates cannot read them. The "verbosity" that is required in moderate doses becomes a fault. Similarly, the scientific conciseness which may otherwise speed comprehension for the specialist may develop into a style so spare that no one can follow it. In extreme cases, the writer begins to feel that all the really "hard" facts are contained in his graphs, drawings, tables, and equations. He therefore writes the fewest possible words needed to introduce these nonverbal forms of information.

CONCLUSION

All of these features of technical writing apply to sentence structure—which is, of course, only one aspect of the problem of writing well. Matters of diction, definition, sentence variety, emphasis, transitions between ideas, and organization are often broader in scope, and in some ways are more important. Analyzing sentences, however, reveals many of the basic reasons why the engineer or scientist writes as he does. Without such knowledge, it is difficult to evaluate technical writing, and therefore difficult to improve it.

Color Their Prose Gray

MELVIN F. ORTH

Abstract—Though surrounded by, fascinating and challenging subjects, too many engineers and scientists write dull reports and papers. More attention to verbs can help alleviate dullness and can promote such qualities as vividness, directness, force, and interest. Passive verb forms can be changed to active; combinations of passive verbs with other lifeless verbs can be reduced through subordination and elimination; and nominalized verbs (verbs forced into noun functions) can be used as true verbs.

Unfortunately, as unnatural as the resultant style will seem to many technical writers and as manipulative as the suggested methods for improvement are, this situation will change only as a new philosophy of style evolves, when the historical adverse influences are overcome. As we hope for this new philosophy, we can at least guard against the squandering of our language's potential.

Too many engineers and scientists resign themselves apparently to an alleged tradition of stylistic dullness in their written reports and papers. Surrounded by some of the most fascinating and challenging subjects in the world, they harmoniously inform their peers (and others who must read their work) in tedious, monotonous, sluggish, lifeless prose. Color their prose gray. So pervasive (and even intimidating) is the tradition that a relatively recent textbook on technical writing suggests a preference for lackluster style since the primary purpose of the technical writer is to inform. Surely this suggestion poses one of the most unsavory non sequiturs between textbook covers. Admittedly, technical writing is not *belles-lettres* prose; but it can be literature. And, as it informs, it can be spirited.

Paying more attention to verbs is one way; maybe the only way for some, probably the best way for most.

A verb, as we well know, is the axis of a sentence; it is the heart. No verb, no sentence. Nothing moves without a verb. The Chinese, reportedly and wisely, call it "the living word." And all rhetoricians testify to its role in effecting life where there is lethargy—though actually there are degrees of liveliness and degrees of lethargy in our verbs. Some of them barely exist. What seems unfortunate is the frequency in which technical writers prefer or force themselves to use the most lethargic verbs and thus fail to realize their potential for vividness, force, life.

Why, for example, should a writer prefer to write "The design is shown in Figure 2" rather than "Figure 2 shows the design"? Or "For better reports visual aids should be included" rather than "Better reports will include visual aids"? or "Visual aids contribute to better reports"? Though one can alter the emphasis in a sentence by changing positions of words or changing the construction in which they appear, how many

technical writers and readers distinguish such subtlety (even subconsciously) in most sentences? In the above examples the shifts in emphasis are too inconsequential to outweigh the advantages of vividness, spirit, force, and economy.

Hundreds of sentences in technical writing offer the same possibilities of change as the above examples:

1. The wave motions are caused by the wind.
The wind causes the wave motions.
2. The metals were fused by the intense heat.
The intense heat fused the metals.
3. The current is increased as the time is decreased.
The current increases as the time decreases.
4. The thigh bone is connected to the hip bone.
The thigh bone connects to the hip bone.

All the numbered and less forceful sentences have verbs in the passive voice (the subject is acted upon); all the revisions have verbs in the active voice (the subject acts, does something). Passive voice verbs always contain at least a form of "to be" (be, is, are, was, were, been) followed by another verb ending most of the time in "ed" or having a past tense form, like the words *built, shown, done, written*.

Passive constructions have their place, but the plethora of unnecessary ones in technical writing bore, confuse, and irritate. Writers evidently think that passive voice equals or approximates that idealized objectivity engineers and scientists seek, and that active voice, conversely, generates subjectivity, the bane of technical communication. The above examples should neutralize that notion.

Even more deadly is the too-frequent combination of passives with the most lethargic verbs we have, the verbs that just exist—the words *be, is, are, was, were, been* again and their close companions (mere linking verbs) *appear, remain, become, seem*, and so on. Prepare for an exciting reading experience:

The tool is made of plastic. It is hollow and is 4 ft. long by 2 in. wide. It is used in a variety of ways and is efficient in all of them. When this tool was first manufactured, it became the most versatile tool on the market.

Another thriller:

The purpose of this report is to propose an alternative method of illumination. Tables were prepared to show the results of the room tests, and are found in the appendix. It was found that the present illumination is satisfactory in the storage room, but that in the assembly room it is below standards. Corners of the room are dark and the machines are shadowed. Lighting would be better if overhead spotlights were installed.

Why need a person write like that? Surely not to be read. Or if to be read, for sedation purposes only.

Manuscript received April 3, 1975.

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A writer can thwart dullness in the above passages by using active voice rather than passive; but he can do even better by subordinating too—that is, by reducing some of the sentences to less than that, and then attaching the reduced construction to a new or remaining sentence. For example, the first passage:

Made of plastic, hollow, and 4 ft. long by 2 in. wide, the tool performs efficiently in various ways. When first manufactured, it superseded in versatility every other tool marketed.

The writer's object, of course, is to reduce the frequency of "nothing" verbs; but once he begins he will effortlessly discover other opportunities for directness, forcefulness, and economy. One way to improve the second thriller follows:

This report proposes alternative illumination. Prepared tables in the appendix show the results of the room tests. Present illumination in the storage room satisfies standards, but that in the assembly room creates dark corners and shadowed machines. Overhead spotlights would improve the lighting.

Another too-common abuse of verb potential in technical writing (besides overuse of passives and the "nothing" verbs in combination with them) arises from nominalizing—converting verbs into nouns, often by adding suffixes:

| | |
|-----------------------|------------------------------|
| do a <i>study</i> | hold a <i>meet(ing)</i> |
| make a <i>reply</i> | give an <i>exam(ination)</i> |
| give a <i>talk</i> | draw a <i>conclu(sion)</i> |
| take a <i>census</i> | reach an <i>agree(ment)</i> |
| come to an <i>end</i> | have a <i>tend(ency)</i> |

and many, many others. Nominalizing certainly adds weightiness to writing, if one wants the kind of weight that slows the reader to a turtle's pace. Nominalizing also frequently forces the writer to use verbs only a slight degree up the scale from the "nothing" verbs, to use such bland verbs as *make*, *do*, *give*, *take*, *come*, *have*. A few sentence examples follow:

1. He made a motion to adjourn.
He moved to adjourn.
2. The committee had a meeting.
The committee met.
3. They gave a demonstration of the process.
They demonstrated the process.

Nominalization, however, can rear its dull and heavy head at sundry times. The wary writer must look constantly for the undeservedly important noun disguising a verb. Varied examples follow:

1. The papers are descriptions of the methods.
The papers describe the methods.
2. The company is in need of new direction.
The company needs new direction.
3. An adjustment of the salary was made.
The salary was adjusted.
4. In the report is a list of flaws.
Flaws are listed in the report.
5. The new procedure will be a great aid to efficiency.
The new procedure will greatly aid efficiency.

The second sentence in all the above examples improves style.

Such are the ways engineers and scientists can attend to their verbs and thus rescue their report writing from an oppressive dullness that betrays the fascination and the challenge of their subject matter. Unfortunately, those ways will seem unnatural and awkward to too many technical writers because of habit and imitation. How they boxed themselves into a writing style so much a travesty of the interest of their subject is another story; but until their natural style more accurately approximates the character of their subject, eliminating dullness and other adverse aspects will consist of manipulating verb forms and other grammatical constructions.

Beyond manipulation lies a plea for a change in philosophy. The precedent of over-reaction set by the 17th-century rebel scientists as they attacked the florid style of the day; the patronizing and condescending attitudes of writers of "pure" literature; the 20th-century aversion to dogged commitment and the effacement of individual identity; lack of accountability; mistaken notions of achieving objectivity; ignorance and docility—all these and surely more have contributed to a philosophy of style in technical writing that finds us today prescribing manipulative measures to retain the best and cure the worst. We can hope that some day, somehow, a more gratifying philosophy of style will evolve than that in evidence today. In the meantime we should learn that our language is too precious to have its potentialities squandered.

APPENDIX G
Proofreader's Marks

| | | | |
|------------------------|--|-------------------|---|
| $\&$ | Delete; take out. | ^ | Insert an inferior letter or numeral. |
| \odot | Turn inverted letter right side up. | <i>lead</i> | A thin metal strip used to widen the space between the lines. |
| <i>stet</i> } | Let it remain; change made was wrong. | <i>space out</i> | Spread words farther apart. |
| \square | Indent one em. | \P | Make a paragraph. |
| \odot | Insert a period. | <i>no</i> \P | Run on without a paragraph. |
| \parallel | The type line is uneven at the side of the page; straighten. | <i>cap.</i> | Use a capital. |
| \times | A broken letter. | <i>l.c.</i> | Use the lower case (small type), i.e., not capitals. |
| \cdot | A hyphen. | <i>s.c.</i> | Small capitals. |
| <i>ital.</i> | Use <i>italics</i> . | <i>w. f.</i> | Wrong font—size or style. |
| \bigcirc | Join together. | <i>font.</i> | Kind of type. |
| $\textcircled{\&}$ | Take out letter and close up. | <i>tr.</i> \sim | Transpose. |
| <i>center</i> | Put in middle of page, or line. | <i>rom.</i> | Use roman letter. |
| \equiv | Straighten lines. | \wedge | Indicates where an insertion is to be made. |
| ∇ | Insert an apostrophe. | <i>Qy. or (?)</i> | Doubt as to spelling, etc. |
| ^ | Insert a comma. | \equiv | Indicates CAPITAL letters. |
| \lceil | Raise the word or letter. | \equiv | Indicates SMALL CAPITAL letters. |
| \lfloor | Lower the word or letter. | \equiv | Indicates <i>italic</i> letters. |
| \sqcup | Bring matter to the left. | \equiv | Indicates boldface letters |
| \sqcup | Bring matter to the right. | \equiv | Indicates BOLDFACE CAPITALS |
| $\#$ | Make a space. | \equiv | Indicates boldface italic |
| ^ | Insert a superior letter or numeral. | | |

α/n
G
 ω/c

We now define $\Omega(n)$ as the sum of all products of functions $F(r)$ in which every one of the n particles of the set n (numbered from 1 to n) is connected to every other particle of the set by at least two paths involving mutually exclusive subsets of intermediate particles, e.g., for $n=3$ we have $\Omega(3) = F(r_{12})F(r_{23})F(r_{13})$. Further, we define functions $H(n)$ as the sums of all possible products of $F(r)$ and $k(r)$ obtainable from $\Omega(n)$ by replacing all or part of any F -function chain by a k -function chain of the same length; e.g., $H(3) = 3k(r_{12})k(r_{23}) \times F(r_{13}) + k(r_{12})k(r_{23})k(r_{13})$.

Finally, we define

$$\alpha = \alpha_r + \sum_{n \geq 2} \frac{\rho_n}{n!} \int \cdots \int [\Omega(n) - f(n)] dr_1 \cdots dr_n \quad (3)$$

\square / lc

[With

$$\square / rom \quad \square \alpha_r = \lim_{r \rightarrow 0} \frac{1}{2} \int_0^r x^2 \int \exp(-ir \cdot t) \frac{\phi^2(t)}{1 - \chi(t)} dt dx. \quad (4)^*$$

APPENDIX H

Equations

HOW TO TYPE EQUATIONS

The following guide has been prepared to assist you in the typing of mathematical equations and chemical formulas. Remember that these are suggestions--equations must be typed to satisfy the requirements of the author. The examples given include Greek letters and demonstrate typical equations of varying degrees of difficulty.

It is not necessary for a typist to have a knowledge of higher mathematics in order to produce satisfactory drafts containing equations, but a familiarity with algebra is helpful and a recognition of the Greek alphabet is necessary. Equation typing is slower than text typing; therefore, the typist should concentrate on accuracy rather than speed. Various conventions of spacing are used; when these become familiar and the special symbols are recognized, practice will bring skill.

Definitions

The dictionary defines a mathematical equation as an expression of equality between two quantities (expressions).

Examples: $ax + by = c$; $43 + 24 = 67$; $bR + gY = z$.

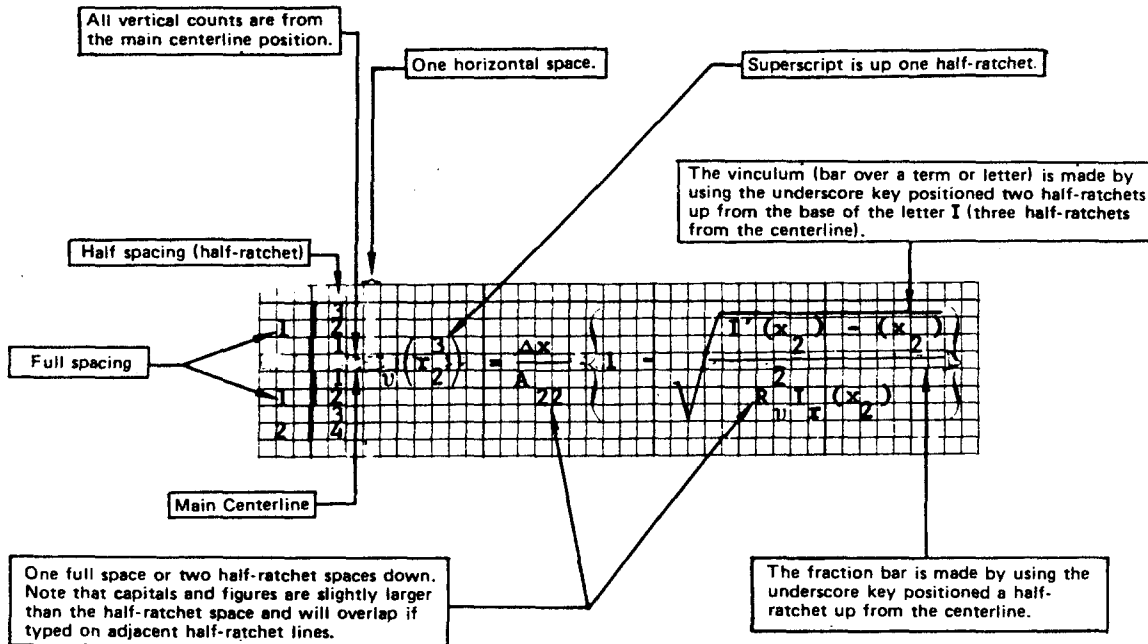
In chemistry an equation is an expression in which symbols and formulas are used to represent a chemical reaction.

Examples: $\text{Na} + \text{Cl} \rightarrow \text{NaCl}$; $2\text{H} + \text{O} \rightarrow \text{H}_2\text{O}$.

Equations are a type of shorthand in which mathematical and chemical relationships and functions are shown by properly spaced and positioned letters and symbols. Each symbol and letter in an equation has a definition. An author will define the symbols and letters, either in the text or in a List of Symbols. Symbols and letters used throughout the report should conform to this listing.

Typewriter Spacing

A properly spaced equation is shown in the chart below. Two vertical blocks correspond to one line of single space typing, and one horizontal block corresponds to the space occupied by one letter. The term "half-ratchet" is used to designate one-half of a vertical line space. The lower half of the vertical line space is used in normal typing. To type above or below the normal typing line (for instance in typing superscripts or subscripts), the typewriter platen must be positioned by using the half-ratchet (if the typewriter is equipped with one) or by hand-rolling the platen.



Preparatory Procedures

Before typing a draft which includes equations, first scan the whole report and note the position of difficult equations or formulas. Then estimate how much space will be required on each page for text and complete equations. This kind of typing requires planning ahead for spacing. The List of Symbols and the text should be consulted for definitions of terms (this will help identify the terms appearing in the equations). Read the equations and resolve any questions about the position which the terms will occupy (above or below the centerline), and whether letters are always capitalized, always lower case, or both; e.g., $w + w' = W$.

Mark all questions about spacing, letters, symbols, and resolve them in one session with the author.

General Rules For Typing Equations

1. Multiplication is indicated by several methods:

5×4 (never use capital X to denote multiplication)

$5 \cdot 4$ (roll platen slightly to place the period)

$dI_1 = -I_1(x)\tau_1(r)dy$ (multiplication indicated by placing factors side by side without space between)

$(a - b)(a + b)$ (parentheses placed next to each other without space between indicate multiplication)

2. Division is indicated by:

$x \div y$, x/y , or $\frac{x}{y}$

3. Punctuate equations when punctuation is consistently indicated by the author in his draft. If he punctuates most of his equations, you can assume he meant to punctuate all of them. Also punctuate when the equation functions as part of a sentence when any sign (i.e., =, \rightarrow) is read as a verb. Punctuation is placed on the centerline (main typing line) of the equation.
4. All equations should be centered on the page.
5. When equation is too long for one line, break it before =; or after + or - when the + or - separates terms. Do not break equation when the + or - is a part of a fraction or a term enclosed in parentheses, brackets, etc.

$$\phi'(t) = (x - x_1)F_x[x_1 + t(x - x_1), y_1 + t(y - y_1)] + \\ (y - y_1)F_y[x_1 + t(x - x_1), y_1 + t(y - y_1)].$$

NOTE: Some authors prefer to place + or - on carryover line; place the sign under the second space to the right of the = sign.

6. Long equations may also be broken before integrals and summations and between sets of parentheses. (This method is less desirable than in paragraph 5.) The author should be consulted when there is no obviously correct place to break an equation.
7. Under exceptional circumstances only should an equation be run over to another page. (The author should always be consulted.)

8. Equations are numbered at the right margin in parentheses. Set a tab so that these numbers are the same distance from the edge of the page.

If the equation has more than one line, the author may prefer to place the equation number at the end of the last line, as shown in paragraph 5. However, other authors prefer to center the equation number as in paragraph 10.

9. If an equation has been included in a sentence, drop down three full spaces and indent (see Equation 2). Bring the first word of the next line of text back to the left-hand margin, and drop down again for the next equation.
10. In a series of equations of parallel or nearly parallel construction, center the longest line and then align the = signs.

$$\begin{aligned} \bar{u}_z &= \frac{1}{r} \frac{\omega}{\omega_r} (r \bar{u}_r) + \frac{\nu \bar{u}_z}{\gamma_z}, \\ &= \alpha \frac{\tau \bar{u}_r}{\omega_z} + \frac{\xi \bar{u}_z}{\alpha_z}, \end{aligned}$$

where

$$\partial^2 = \frac{\mu + 2\nu}{r}, \quad \phi^2 = \frac{\mu}{\partial}.$$

Horizontal Spacing

1. Leave one space before and after +, -, =, · (times) signs, and the abbreviations cos (cosine), tan (tangent), sin (sine), and exp (exponent), except when a parenthesis follows.

Example: $A + B - c = \cos \theta \exp (-i\omega t).$

Exception: In typing superscripts and subscripts with the above-mentioned signs, do not space before or after +, -, =, and ·.

$$A^{r-2} + B_{n=1} = D.$$

When a fraction is a minus quantity, it is sometimes necessary to leave space so that the minus sign (hyphen key) will not run into the fraction bar (underscore positioned a half-ratchet up from the hyphen).

$$\gamma E^2 = 2ab\omega - \frac{dx}{dy}.$$

2. When a minus quantity is used next to a single character on either side of an = sign, leave no space.

$$-B = A + C, \quad 7 - 9 = -2.$$

3. Leave no space before or after parentheses, brackets, or braces when the expression enclosed is immediately preceded or followed by letter or number symbols.

$$A(B + C)D - E = -F.$$

4. Leave one space before and after the longest expression at the top and bottom of a summation sign (similar to capital sigma).

$$A \sum_{m=1}^{1+K=m} B(D) = fe^{-i\omega} dx_2.$$

Leave no space between terms at the top and bottom of summations. Center the smaller terms with the larger. The top and bottom bars of a summation sign do not have to cover the term above or below it unless it is necessary to clarity. The summation sign must be as tall as the highest part of the equation following it.

5. The integral sign (see below) frequently has superscripts or subscripts which are called limits. The term used for the upper limit of an integral is positioned one space to the right of the term used for the lower limit. As with summation signs, no spaces are left between terms in these super- or subscripts.

$$A = \int_{a+c}^{de} LC\xi^2 \mathcal{L}(\xi \wedge t)_1 dt.$$

6. Leave one space before and after fractions.

$$\frac{dx}{dy} \frac{2ab}{c} = A + \cos \theta.$$

Vertical Spacing

1. Leave three spaces between the text and the top character of the equation and between the lowest character and the following text.
2. Place each simple superscript (or subscript) a half-ratchet above (or below) the character to which it refers.
3. Complex superscripts must be built up by half-ratchets so that the lowest character will be a half-ratchet above the symbol which is superscripted.
4. Subscripts are positioned the same as superscripts, each succeeding subscript position placed a half-ratchet below and next to the term to which it refers.

$$M_2 = n \quad -e \frac{x+3}{\beta_2} \quad dx dy + \frac{\left(d^2 x_2\right)^2}{X_{nd} y} + c_2^3 = \frac{a}{b} .$$

- NOTES:
1. Letters and numerals require four half-ratchets above the centerline in this example.
 2. Note that fraction $\frac{a}{b}$ requires three half-ratchets as does the expression c_2^3 . The c and the fraction bar are on the centerline. The underscore was used to make the fraction bar by moving up a half-ratchet from the equal (normal underscore for the a).
 3. To count accurately the number of half-ratchets needed to type an equation, the typist must understand from the rough draft the position each number, letter, or symbol will occupy.

Additional Techniques

1. Use the slash to write simple fractions appearing in text or as exponents, e.g., 3/5 inch, $x^{1/2}$, $\omega^{2/3}$.
2. Use the underscore key to place a bar over a letter; on some typewriters (even those with half-ratchets) this means hand-rolling the platen. Care must be taken that the bar does not cut the top of the letter or stand

so high above the letter that it does not appear to go with the letter. Extra space must be above the bar if it appears in the denominator of a fraction, (see \overline{Z}_1).

$$X_1 = \overline{u}_r \beta \frac{a^2}{Z_1 B} - 2 \frac{B^2}{\omega^2} \frac{h \tau_1}{2}.$$

3. To place a dot over a letter, backspace over the letter and move the platen until the tops of the tall letters are visible over the guide rule, then strike the period key.

$$\dot{\omega}(b)^2 + \dot{p}_0 = \dot{\rho}(\rho_0 - \dot{\rho}_0^1).$$

4. Superscripts are positioned above subscripts to save space.

$$a_2^3 - p_1^2 - B_1 h.$$

5. Parentheses should be as tall as the terms they enclose.

$$\text{Example: } \tau_{r-1} \leq \frac{r(w-1)}{v-r+1} \binom{v}{r} (w-1)^{v-r} \tau_r = \binom{v}{r-1} (w-1)^{v-(r-1)} \tau_r$$

Exception: Use typewriter parentheses when enclosing one superscript or one subscript but not for a fraction.

$$(a^2) \text{ or } (a_2) \text{ but not } \left(\frac{a}{b}\right).$$

When a term enclosed in parentheses is raised to a power, the power is placed outside the parentheses and positioned a half-ratchet above the term.

$$A(2\beta^2 - k_s^2)^2.$$

6. Parentheses, brackets, and braces enclose terms which are to be treated as units. The innermost term is enclosed in parentheses, the next method of enclosure is brackets, and finally (in this example) braces.

$$\mu_v(r_2) = \frac{x_2}{n_{22}} 1 - \left\{ \sqrt{\frac{I_v'(x_2) - I_v(x_2)}{2[R_v I_v(x_2)]}} + \left[\frac{1}{1 - \mu_v(r_1)(A_{21}/\omega x)} \right] \right\}.$$

7. To type a fraction such as:

$$x + b_2 = \frac{z^2}{x^2 + 2\mu - n_{a+b} + W^2}$$

\nearrow numerator
 \rightarrow centerline and fraction bar.
 \searrow denominator

- a. Type over to the fraction.
- b. Type the longest part first (in this case, the denominator).
- c. Roll one full space above the highest character in the denominator and completely cover the denominator with the fraction bar. Count the number of underscores used, backspace half that number, and then center the numerator--as a title is centered on a page.

Typing Equations on Typewriters Not Equipped With a Half-Ratchet

Simple equations may be typed on typewriters not equipped with a half-ratchet by hand-rolling the platen to the proper position for superscripts or subscripts. Use the line-position reset lever to type above and below the line, and return to the original line position. Position the superscripts and subscripts in the white space above and below the typing line. To position superscripts, roll to the top of a small letter (such as an a or c). To position subscripts, roll until the top of the subscript letter is in line with the bottom of the letter on the centerline.

Example: a_2^3

\nearrow superscript
 \rightarrow centerline
 \searrow subscript

To type an expression such as:

"The expression $d^2x_2y^2n_4$ is substituted for $d^3x_4y^2n_5$ when"

First, type all letters and symbols on the centerline of the expression and leave space for each superscript and subscript.

"The expression d x y n is substituted for d x y n when"

Then, insert the superscripts (release the line-position reset lever and roll the platen toward you).

"The expression $d^2x y^2n$ is substituted for $d^3x y^2n$ when"

Finally, insert the subscripts (roll the platen away from you). Re-engage the line position reset lever to return to the typing line.

Reference Sheet For Mathematical Symbols

The following mathematical symbols are typed with one space before and one space after the symbol:

| | | | |
|-----------|--------------------------|--------------------|---|
| Σ | Summation | \leq | Less than or equal to |
| Π | Product | $\sqrt{\quad}$ | Square root; radical |
| ∞ | Infinity | x or \cdot | Multiplied by; times |
| \propto | Proportional to | \pm | Plus or minus |
| \sim | Similar or equivalent to | \parallel | Parallel to |
| \equiv | Identical to | $ a $ | Absolute value of |
| \neq | Is not identical to | \rightarrow | Approaches; corresponds to |
| \approx | Nearly equals | \therefore | Therefore |
| \nless | Does not equal | \because | Because or since |
| $>$ | Greater than | \underline{i} | Vector notation (single underscore over a single letter) |
| $<$ | Less than | $\overline{c - d}$ | Vinculum (underscore over 2 or more math expressions--means everything under it is considered a single term. Is equivalent to parentheses or brackets). |
| $>>$ | Much Greater than | | |
| $<<$ | Much Less than | | |
| \geq | Greater than or equal to | | |

The following mathematical symbols are typed with the spacing indicated:

| | | |
|------------|----------------------|--|
| ∂ | Partial differential | Horizontal space before the symbol, no horizontal space between the partial differential and the symbol that follows. $\partial y, \partial x$ |
| Δ | Finite difference | There is no horizontal space between the finite difference and the symbol that follows. Δx |
| $!$ | Factorial | Do not space between the symbol and the factorial. $5!$ |
| \int | Integral | Space before and after. If there are upper and lower limits, do not leave a space between the symbol and the limit. Leave a space after the limit. |

The following abbreviations are typed in lower-case letters with no period at the end. They are set off by one space on either side except when a superscript, subscript, or parenthesis follows--there is no space between the abbreviation and the superscript, subscript, or parenthesis.

| | | |
|------------------------|---|---------------|
| sin = sine | cos = cosine | tan = tangent |
| cot = cotangent | log = logarithm | sec = secant |
| e or exp = exponential | Usually written exp. | |
| h = hyperbolic | Follows one of the above abbreviations with no space between the abbreviations and the hyperbolic (sinh, cosh, etc.). | |

BIBLIOGRAPHY

A. Annotated Authorities

Bernstein, Theodore M. The Careful Writer. New York: Atheneum Press, 1973.

How many writers are aware that "eke" means to add, increase, supplement; not to squeeze out? More important, the book explains when to use the hyphen, the difference between "presume" and "assume," when to use "persons" instead of "people." The word "via," it explains, means by way of, geographically, not by means of. This book is an ego-satisfying way to justify changes.

Berenson, Conrad and Raymond Colton. Research and Report Writing for Business and Economics. New York: Random House, 1971.

A rather scholarly work, this guide concentrates on economics reports and is especially good in the field of charts, histograms, and accounting. An interesting, if not critical, addition to any library.

Campbell, William G. and Stephen V. Ballou. Form and Style: Theses, Reports, Term Papers. 4th ed. Boston: Houghton Mifflin Co, 1974.

This unpretentious, spiral-spined, paper-bound book has been around since the 1930s. Its very unpretentiousness will probably cause it to go undetected on bookstore shelves by a technical writer intent on quality. It would indeed be a sad oversight because the book is crammed with practical advice on formatting, outlining, revising, and researching. Its most important section deals with footnotes, references, and bibliography. Step by step it leads the reader through the footnote jungle, explaining and SHOWING him how to compose good, informative footnotes and references for works extending from fiction through reference works and from biblical passages to government documents. Chock-full of the mechanics of writing, this book not only explains, but also demonstrates.

Lapedes, Daniel N., ed. Dictionary of Scientific and Technical terms. New York: McGraw-Hill Book Co, 1974.

No single aid is as important as this 3-inch-thick volume for the writer who must untangle jargon from slang and who must clarify terms taken for granted by the scientific community. The writer can get the real meaning of "flameout, air lock, criticality, relativistic, exfoliation corrosion, etc," and know what the author is trying to say in order to help him issue a clear and professional report.

Linton, Calvin D. Effective Revenue Writing. US, Internal Revenue Service Training Manual No. 129 (rev 7-62). Washington: Superintendent of Documents, GPO, July 1961.

This out-of-print training manual is a delightful surprise: expecting the usual stiff bureaucratese, the reader is treated instead to English that is clear, sensible, and attainable. Linton follows his own advice, making this book one to rival William Strunk's immortal Elements of Style.



A Manual of Style. 12th ed. Chicago: The University of Chicago Press, 1974.

This tremendous treasurehouse of information is the bible for most nontechnical writing throughout the country. It introduces the reader to such mysteries as bookmaking, production, and printing. The largest and, for the technical writer, the most important portion deals with style. In almost exhaustive detail it explains punctuation, spelling, names, and terms, numbers, foreign language treatment, abbreviations, hyphenation, etc. All subjects are treated thoroughly and authoritatively. For instance, in paragraph 5.17 it performs such delicate maneuvers as asking a question within a declarative statement:

"A question mark should be retained at the end of an interrogative sentence that is included within another sentence:

How can the two men be reconciled? was on everyone's mind.

The question still to be decided on was, Which of the two strategies would be less likely to provoke opposition?"

A MUST ON EVERY WRITER'S SHELF

Metric Practice Guide. Philadelphia: The American Society for Testing and Materials (ASTM) 1976.

The nation is going metric and metric means international. Nothing will brake this headlong plunge into a rational, logical, and consistent system of measurement, whether the scientific or lay community approves it or not. This thin pamphlet is the VOICE OF AUTHORITY in converting US units into SI (metric) units. It also contains such tidbits as the fact that the "litre" really represents two different quantities and should not be used. Use of the term "metric ton" (or just "tonne") is strongly discouraged.

A MOST VALUABLE AIDE, INDISPENSIBLE FOR HIGHLY TECHNICAL REPORTS --
Especially if you have a calculator.

Reisman, S. J., ed. A Style Manual: For Technical Writers and Editors. New York: The Macmillan Company, 1963.

Written for the Lockheed Missiles and Space Company, this manual suffers from the inconsistencies that plague a multi-author book. However, it is based on a bibliography of almost 60 titles. It is clear, concise, well-laid out, and copiously illustrated. One weakness is in its use of bullets; it gives hundreds of examples in the usage of bullets but its punctuation of this element is distressingly inconsistent and seems to depend on which author wrote a particular section. It is especially strong in format but weak in citations.

Tichy, H. J. Effective Writing: For Engineers, Managers, Scientists. New York: John Wiley & Sons, Inc, 1966.

There is no better book on the subject. Long-suffering writers may wish that engineers, managers, and scientists would, indeed, read and abide by its advice; otherwise, move aside and let those who can handle the writing do so. However, if one is to believe the author, it will be a long time acomin':

" . . . a man's feelings about his writing are more sensitive and tender than his feeling about his performance in his science or technology. . . he takes criticism as a reflection on his inner self. An engineer will defend at length a dangling modifier or pronoun without an antecedent but he will correct an error in engineering the moment it is pointed out to him"

This excellent book is the text for Sandia's in-house course in technical writing, a well-deserved honor. Clear and concise. Keep this book handy.

Turabian, Kate L. A Manual for Writers. 4th ed. Chicago: The University of Chicago Press, 1973.

A sister to the Chicago Style Manual, this little manual is the preference of many colleges and universities, including several colleges at the University of New Mexico. It parallels Chicago in most essential points, is more concise, more simply organized and, for the busy writer, more useful.

US Government Printing Office Style Manual. Washington: United States Government Printing Office (GPO), 1973.

A camel, a pundit once pontificated, is a horse put together by a committee; utility, rather than aesthetics, was the criterion. Like the camel, the GPO suffers from inherent inconsistencies. In the list of abbreviations, for example, it capitalizes MF (medium frequency) yet puts lf and hf (low and high frequency) in lower case. It is even more jolting for vhf and VLF because they are only a few lines apart. Although most modern authorities are not capitalizing roman or arabic when referring to numerals, the GPO cannot make up its mind, sometimes capitalizing, sometimes not. However, if one can endure the rather stiff, bureaucratic tone, average the inconsistencies, and accept the fact that it is THE AUTHORITY for all government and government-related work, he will find it a useful guide. It is

especially valuable for abbreviations, numbers, compounding, and capitalization. Its format resembles that of the Chicago Style Manual.

B. Other Authorities

Compositor Guidelines. Albuquerque: Sandia Laboratories, nd.

Hathwell, David and A. W. Kenneth Metzner, eds, Style Manual: For Guidance in Preparation of Papers for Journals Published by the American Institute of Physics and its Member Societies. 3rd ed. New York: American Institute of Physics Inc, 1978.

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McDonald, G. Corey. Recommended Use of SI Units (Metric System) at Sandia Laboratories SLA-73-0159A. Albuquerque: Sandia Laboratories, August 1973.

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INDEX

References are to paragraph numbers unless otherwise stated.

- Aberration
 - Of a syllabus, 2.7
 - Of English, 5.1
- Abbreviation(s)
 - As jargon, 4.4.1
 - Capitalizing, 4.4.1 and .3
 - Not capitalizing, 4.4.3
 - Expansion of, 4.4.1
 - General, 4.4
 - In figures, 4.2.1.1
 - Appendix, 4.2.1.2
 - In journal titles, 3.1.3.7
 - In measurements, 4.3.3
 - In tables, 4.2.2.2
 - In time, 4.3.9b
 - Of bit, 5.4.16
 - Of litre, 5.4.7
 - Of Rad, 5.4.6
 - Of Roentgen, 5.4.6
 - Plurals of, 4.4.2
 - Punctuation of, 4.4.4
 - SI, 4.4.1
 - Technical, 4.4.1
- Abstract, 1.1
- Acknowledgment, 1.2
- Adjective(s)
 - As verbs, 5.1
 - Nouns as, 5.3.2
 - Unit modifiers, 5.2.1.1
- Aesthetics, 3.1.2.2
- Affectation, 4.3.9e
- Agency (s)
 - Publishing (in citations), 3.1.3.6
- Alphabetical order
 - Appendix, 3.2.1; 3.3
 - Bibliography, 3.4.1.1; 3.4.2
 - Glossary, 3.3
 - Index, 3.5
 - Nomenclature, 1.8
- AM (am), p7; 4.3.9d
- American(s)
 - Hyphenated, 5.2.2
- Anachronism(s), 5.4
- Anno Mundi, See AM
- Annotation(s), 3.1.3.4b
- Anonymous author, 3.1.3.1f
- Ante meridiem, See AM
- Anthology, 3.1.3.1e; 3.1.3.2b
- Apostrophe
 - Before "s" in abbreviations, 4.4.2
 - Before "s" in numbers, 4.3.2
 - Before abbreviated year
- Appendix(es)
 - Content, 3.2.2
 - Credit, 3.2.3
 - Figures, 4.2.1.2
 - In equations, 4.5
 - Placement, 3.2; 3.2.1; 3.3
- Applied Science and Technology Index, 3.1.3.7
- Arabic
 - Not capitalized, p7
 - Chapters and sections, 2.8
 - In Bibliography, 3.4.2
 - In Figures, 4.2.1.1
 - In footnotes, 4.1.4
 - In reference citations, 3.1.2
 - In tables, 4.2.2.1
 - To number equations, 4.5
 - Volume numbers in references, 3.1.3.7b
 - When spelled out, 4.3.1
- Arrangement
 - Of bibliography, 3.4.1
 - Of preliminaries, 1.
 - Of texts, 1.7
- Asterisk(s) in footnotes, 4.1.5
- Authenticity, 1.3
- Author(s)
 - Hostility of, p8; 4.4.1
 - In bibliography, 3.4.1.1; 3.4.1.2
 - multiworks, 3.4.1.1a
 - surname first, 3.4.1.1
 - In categories, 3.4.2
 - In references, 3.1.3; 3.1.3.1
 - multiple, 3.1.3.7a,b
 - multivolume, 3.1.3.5
 - none, 3.1.3.1e
 - periodicals/journals, 3.1.3.7
 - sandia Reports, 3.1.3.9
 - unknown, 3.1.3.1f
 - unlisted, 3.1.3.1c
 - Patronizing, 5.4.10
- Authority
 - Of a report, 1.3
 - References, 3.1
 - Style Manuals, p7
- Back Matter, 3.
- Bibliography,
 - Author, 3.4.1.1
 - Categorization, 3.4.2
 - Classified reports, 3.1.3.10
 - Contents of, 3.4
 - Format of, 3.4.1
 - General, pp 7, 9
 - Glossary, in relation to, 3.3
 - Punctuation in, 3.4.1.2
- Billion; discouraged, 5.4.15
- Bit; meaning of, 5.4.16
- Book; in bibliography, 3.4.2
- Brackets
 - Around citations, 3.1.2.1
 - Author's name in references, 3.1.3.1c
 - In translations of title, 3.1.3.2c
- Bullets, 2.6
- Buzzwords, 5.1
- Calibre, 4.3.6
- Callout(s)
 - Of appendixes, 3.2.1
 - Of figures, 4.2.1.1
 - Of tables, 4.2.2.1

Capitalization
 In Bibliography, 3.4.2
 In bullets, 2.7
 In caption, 4.2.1.3
 In Glossary, 3.3
 In legend, 4.2.1.4
 Of Appendix

Caption(s)
 Compared with legend, 4.2.1.3
 In table of Contents, 1.5
 Placement of, 4.2.1

Category(s)
 In Abstract 1.1
 In Bibliography, 3.4.2
 Of references, 3.1.3

Centering
 Of centerhead, k2.2
 Of drophead, 2.1

Centerhead(s)
 In table of Contents, 1.5
 Nomenclature, 1.8
 Placement of, 2.2

Centi-; discouraged, 5.4.12

Century(s)
 Capitalization of, 4.3.9f
 Not expressed in figures, 4.3.9

Chapter(s)
 As a drophead, 2.1
 Authorship, 3.1.3.1e
 Footnote, 4.1.4
 How numbered, k2.8

Charge; nuclear, 14.1.1

Charts; as figures, 4.2.1

Chronology; list in order of, 2.5

Cipher (zero), 4.3.6

Citation
 In footnotes, 4.1.1; 4.1.4
 In reference Section, 3.4
 Method, 3.1.2
 Multiple, 3.1.2.2
 Inclusive, 3.1.2.3
 Not inclusive, 3.1.2.4
 Placement, 3.1.2.1

City of publication (references), 3.1.3.3c

Clarity
 As criterion, p9; 2.; 3.1.1
 In abbreviations, 4.4.1
 In equations, 4.5
 Versus jargon, p8

Classical works, 3.1

Classification
 In Bibliography, 3.1.3.9
 In reports, 3.1.3.9

Clock, 24-hour, 4.3.9d,e

Collections, referenced, 3.1.3.8

Colon
 Before subtitles, 3.1.3.2
 Between hours/minutes, 4.3.9d
 In bullets, 2.6
 In facts of publication, 3.1.3.3c
 In journal references, 3.1.3.7b,c,d

Comma(s)
 In Bibliography, 3.4.1.2
 In bullets, 2.7
 In references
 after author, 3.1.3.1
 after facts of publication, 3.1.3.3f
 after title, 3.1.3.3c
 in facts of publication, 3.1.3.3e
 in government publications, 3.1.3.6
 in series, 5.4.13
 omitted between 1000s, 4.3.4
 omitted in multiple citations, 5.4.9

Committee(s); order of jurisdiction, 3.1.3.6

Community
 As exclusion area, 4.4.1
 Military, 4.3.9e
 Scientific, 4.3.4

Communication, understandable, p8

Compiler; in references, 3.1.3.1; 3.1.3.1d, e

Complete sentence; in bullets, 2.6; 2.7

Compounds; hyphens, 5.2.1

Conclusions, responsibility to cite, 3.1

Congress; order of jurisdiction, 3.1.3.6

Conjunction, coordinating, in bullets, 2.7

Consistency
 General, p7
 Journal title abbreviations, 3.1.3.7
 Of references, 3.1.1

Contents
 Of figures, 4.2.1.4
 Of preliminaries, 1.
 Of summaries, 1.7
 Table of; location, 1.3; 1.5
 Table of; location of figures in, 4.2.1.4
 Table of; location of tables in, 4.2.1.4

Conversation, telephone; cited, 3.1.3.8

Copyright release, 4.6

Courtesy
 Of Bibliography, 3.4
 Of expanding abbreviations, 4.4.1
 Of footnotes, 4.1.3
 Of Glossary, 3.3
 Of the writer, 4.2.1

Credit
 Acknowledgment
 Citations
 For appendixes

Criterion
 In abbreviation; 4.4.1
 See Clarity

Cubing; discouraged, 5.4.2

Cycle(s), discouraged, 5.4.3

Dagger; as a symbol, 4.1.5

Dash
 After run-in sidehead, 2.4
 With citation superscript, 3.1.2.1

Data; singular/plural, 5.4.1.4

Date
 In Bibliography, 3.4.1.1a
 In references, 3.1.3.3f; 3.1.3.7e

Datum; seldom used, 5.4.1.4

Decade(s)
 Not capitalized, 4.3.9f
 Not expressed in figures, 4.3.9

Deci-; discouraged, 5.4.12

Decimals
 Commas substituted for, 4.3.4
 Expressed in figures, 4.3.6
 In tables, 4.2.2.3

Decimetre, cubic; preferred to litre, 5.4.7

Deka-; use discouraged, 5.4.12

Dictionary(s)
 As references, pp7,9
 For hyphens, 5.2.1

Dissertation(s); how cited, 3.1.3.8

Distribution; limited, 3.1.3.10

Division; of report, 2.; 2.4

Drawing(s)
 As figures, 4.2.1
 As frontispiece, 1.6
 Drophead; placement of, 2.1

Edition
 In references, 3.1.3.3a
 Mentioned in preface, 1.4

Editor
 Cited, 3.1.3.1; 3.1.3.1d,e; 3.1.3.2b
 Ed See editor
 Element, atomic, 4.4.1
 Engineer(s)
 Clarity, p8
 Jargon, 4.4.1; 5.1
 Equation(s); general, 4.5
 Et al; in references, 3.1.3.1b
 European languages, in references, 3.1.3.2c
 Executive orders, 3.1.3.10
 Expansion of abbreviations, 4.4.1

 Facts
 As data, 5.4.14
 Cited, 3.1
 Of publication (references), 3.1.3; 3.1.3.7c
 city, 3.1.3.3c
 date, 3.1.3.3f
 edition, 3.1.3.3c
 in Bibliography, 3.4.1.2
 no city, 3.1.3.3d
 publisher, 3.1.3.3e
 Figures
 Callout, 4.2.1.1
 Caption, 4.2.1.4
 General, 4.2.1
 In table of Contents, 1.5
 Legend, 4.2.1.4
 Placement, 4.2.1.2
 Fiscal year; See year
 Footnote
 Authority (cited), p7; 3.1
 Content, 4.1.3
 Format, 4.1.4
 In tables, 4.1.2
 Location, 4.1.1
 Symbols, 4.1.5
 Foreign languages; cited, 3.1.3.2c
 Fractions; as figures, 4.3.6
 Foreword, 1.3
 Form, p9
 Format
 Of Bibliography, 3.4.1
 Of bullet, 2.7
 Of footnotes, 4.1.4
 Of guide, p9
 Freedom of Information Act, 3.1.3.10
 Frontispiece, 1.6

 General topic (centerhead), 2.3
 Giga-; preferred to billion, 5.4.15
 Glossary
 Defined, 1.8
 Placement, 3.3
 Graphics, 4.2.1
 Greek; in nomenclature, 1.8

 Honesty, intellectual, 3.1
 Hour(s)
 As redundancy, 4.3.9e
 Separated from minutes, 4.3.9d
 Heading(s), 2.
 Hecto-; use discouraged, k5.4.12
 Hertz, 5.4.3
 House, Congress, 3.1.3.6
 H.W. Wilson Indexes, 3.1.3.7a
 Hyphenation
 After "quasi," 5.2.1.2
 Explained, p8
 General, 5.2.2
 In compounds, 5.2.1
 In unit modifiers, 5.2.1.1

 IDO; See Distribution, limited
 Indentation
 Bibliography, 3.4.1.2
 Glossary, 3.3
 References, 3.1.3
 Run-in sidehead, 2.3
 Index, 3.5
 Information
 Ancillary, 3.1.3; 3.1.3.4; 3.1.3.5a
 As data, 5.4.14
 In Bibliography, 3.4.1.2
 Intermediate, 3.1.3.5a
 Initial(s)
 Letters capitalized, 2.2; 2.7
 Integrity
 Generally, 1.3
 Intellectual, 4.6
 International
 Clock, 4.3.9d
 Scientific community, 4.3.4
 Interview; cited, 3.1.3.8
 Introduction; placement, 1.7
 Introductory text, 2.3
 -ize, See Jargon
 Jargon
 Compared to abbreviations
 and acronyms, 4.4.1
 General, 5.1
 Introduced, p8
 See Buzzwords
 Journal(s); cited, 3.1.3.7
 Jurisdiction
 In citations, 3.1.3.6
 In government publications, 3.1.3.6
 Kelvin
 Explained, p7
 No degree mark, 5.4.1
 Kilogram force; discouraged, 5.4.4
 Knowledge, p8

 Language(s)
 Foreign, 3.1.3.2e
 Patronizing, 5.4.10
 Specialized, 5.1
 Legal documents; cited, 3.1
 Legend
 Explained, 4.2.1.4
 In table of Contents, 1.5
 Placement, 4.2.1
 Letters; cited, 3.1.3.8
 Library, Sandia Technical, 4.6
 Limiting unit (for figures) 4.3.1
 Liter, See litre
 Litre
 Correct spelling, 5.4.7
 Use discouraged, 5.4.7

 Magazine(s); cited, 3.1.3.7b
 Manuscript(s); cited, 3.1.3.8
 Measurement(s)
 Expressed in figures, 4.3.1.1
 See Bit
 Megagram; preferred to ton or tonne, 5.4.5
 Memorandum(s)
 Cited, 3.1.3.8
 Internal, 3.1.3.10
 Meter, See Metre
 Metre; preferred to meter, 5.4.7
 Metric
 System, 5.4
 Ton, tonne, 5.4.5
 Micrometer; preferred to micron, k5.4.11
 Micron; discontinued, 5.4.11

Military
 Clock, 4.3.9e
 Community, 4.3.9e
 Million vs billion, 5.4.15
 Minute(s) vs hours, 4.3.9d
 Month
 In journal citations, 3.1.3.7c,e
 No comma between year, 4.3.9da
 Multiple volumes; cited, 3.1.3.5

 Newspaper(s); cited, 3.1.3.7b
 Newton(s), 5.4.4
 Nomenclature, 1.8
 Note(s); after Facts of Pub, 3.1.3.4b
 Nouns
 As adjectives, 5.1; 5.3.2
 As verbs, p8; 5.1; 5.3.3
 Novels; not discussed, 3.1
 NP, 3.1.3.2d
 Nuclear charge, 4.1.1
 Numbers
 Arabic, See arabic
 At start of sentence, 4.3.7
 Divisions of report, 2.8
 Equations, 4.5
 Figures in appendix
 Fractions, 4.3.6
 In Bibliography, 3.4.1
 In index, 3.5
 In ratios, 4.3.8
 In references
 edition, 3.1.3.3a
 government pubs, 3.1.3.6
 issue, 3.1.3.7c, d
 volume, 3.1.3.7a, b
 In tables, 4.2.2.3
 In time, 4.3.9
 Mass, 4.1.1
 Ordinals vs cardinals, 4.3.1.2
 Plurals, 4.3.2
 Spaces between 1000s, 4.3.4
 Spelled out, 4.3.1
 With measures, 4.3.1.1
 With military units, k4.3.5
 With symbols, 4.3.3
 Numerical order
 In Bibliography, 3.4.2
 In references, 3.1.2.4
 Of figures, 4.2.1.1
 Of tables, 4.2.2.1

 Office Procedures Manual, 4.5
 Opinion
 Cited, 3.1.3.8f
 Need to cite, 3.1

 P (pp); in citation, 3.1.3.4a; 3.1.3.5b
 Page(s)
 Numbered, 3.1.3.4a
 Numbered/index, 3.5
 Parallels, as symbols, 1.8; 4.1.5
 Parenthesis
 Citations, 3.1.1
 In Bibliography, 3.4.1.2
 In equations, 4.5
 In references
 after title, 3.1.3.2
 facts of pub, 3.1.3.3; 3.1.3.3f
 periodicals, 3.1.3.7c
 In tables, 4.2.2.1
 Numbered paragraphs, 2.5

 Parochialism, scientific, p8
 Pascal; preferred over torr, 5.4.8
 Patronizing language, 5.4.10
 Passive voice, p8
 Pedantry vs jargon, p8
 Percent
 Symbol in nomenclature, 1.8
 Symbol preferred, 4.3.6
 Period,
 After abbreviations, 4.1.1; 4.4.4
 Between 1000s, 4.3.4
 In Bibliography, 3.4.1.1a; 3.4.1.2
 In Glossary, 3.3
 In references
 after facts of pub, 3.1.3.3f
 after note, 3.1.3.4a, b
 journals, 3.1.3.7e
 Periodicals
 In Bibliography, 3.4.2
 In references, 3.1.3.7
 Photograph
 As figure, 4.2.1
 As frontispiece, 1.6
 Pluralizing
 Abbreviations, 4.4.2
 Numbers, 4.3.2
 Placement
 Of figures, 4.2.1.2
 Of preliminary data, 1.
 Of reference citations, 3.1.2.1
 Of tables, 4.2.2.2
 Plays; not discussed, 3.1
 PM, p7, 4.3.9d
 Poems; not discussed, 3.1
 Post Meridiem, See PM
 Precision in measuring, 5.1
 Preface; placement, 1.4
 Preliminary data; defined, 1.
 Pressure, See Torr, Pascal
 Prior word, See Preface, Foreword
 Probabilities; how cited, 4.3.6
 Procedural guide, 2.8
 Publication(s)
 Facts of, See Facts
 in Bibliography, 3.4.2
 in references
 place of, 3.1.3.3dc
 place of unknown, 3.1.3.3d
 government pubs, 3.1.3.6
 Sandia reports
 Public domain, 4.6
 Publisher; cited, 3.1.3.3c, e
 Publishing house, See Publisher
 Punctuation
 In abbreviations, 4.4.4
 In Bibliography, 3.4.1; 3.4.1.2
 In bullets, 2.7

 Quarters (time), 4.3.9
 Quasi-
 Statutory docs, not discussed, p7; 3.1
 With/without hyphen, See hyphenation
 Quotation
 Marks; in citations, 3.1.3.1e; 3.1.3.7
 Need to cite, 3.1; 3.1.2

Radiation absorbed dose, See Rad
 Rad, 5.4.6
 Ratio(s); how listed, 4.3.8
 Rd, See Rad
 Reader
 As anthology, 3.1.3.1e; 3.1.3.2b
 Distracted, 4.1.3
 Non-community, 4.4.1
 Patronized, 5.4.10
 Redundancy; in time, 4.3.9e
 References
 Ancillary information, 3.1.3.4
 Author, 3.1.3.1
 Citation number, See cite
 Compared to Bibliography, 3.4.1.2
 Facts of publication, 3.1.3.3
 Format of, 3.1.3
 Government pubs, 3.1.3.6
 In table of contents, 1.5
 Location, 1.8
 Multiple volumes, 3.1.3.5
 Periodicals/journals, 3.1.3.7
 Responsibility of, 3.1
 Samples, 3.1.3.5b
 Section, 3.1.3; 3.4
 Sandia report, 3.1.3.9; 4.1.3
 Title, 3.1.3.2
 To classified reports, 3.1.3.9
 Reference works, 2.8
 Relationship(s); how listed, 4.3.6
 Relative importance; how listed, 2.5
 Reports
 Classified, 4.1.3
 Copyright duplication, 4.6
 Sandia; cited, 3.1.3.9; 4.1.3
 Responsibility of writer, 1.
 Reprint(s) 1.4
 Revision
 In citation, 3.1.3.3b
 In preface, 1.4
 Roentgen; use discouraged, 5.4.6
 Roman numerals, 4.3.5
 Run-in sidehead, 2.4
 Scientific
 Equations, 4.5
 International community, 4.3.4; 5.4; 5.4.7
 Journal(s), 3.1.3.7
 Measurement(s), See Buzzwords
 Paper(s), 3.1.3.8
 Reports; anachronisms, 5.4
 Usage of symbols, 4.3.6
 Writing, 4.3.9d, 5.2.1
 Scientists, See Jargon
 Scripture, not discussed, 3.1
 SDO, See Distribution, limited
 Season
 In references, 3.1.3.7c
 Not expressed in figures, 4.3.9a
 Section(s)
 Footnotes, 4.1.4
 How numbered, 2.8
 Mark (symbol), 4.1.5
 Numbered, 2.1
 SEDO, See Distribution, limited
 Semantics, 5.1
 Semicolon, in facts of pub, 3.1.3.3a
 Senate; in citations, 3.1.3.6
 Separated sidehead, 2.1
 Series; in references, 3.1.3.5
 Short title; in references, 3.1.3.9
 Size language, See Jargon
 Sources
 Primary; in Bibliography, 3.4.2
 Secondary; in Bibliography, 3.4.2
 unpublished, in references, 3.1.3.8
 Speeches; cited, 3.1.3.8
 Spaces
 Between multiple citations, 5.4.9
 Between 1000s, See Commas
 Squaring; discouraged, 5.4.2
 Statistics; how listed, 4.3.6
 Subheading(s), 1.5
 Statutory documents; not discussed, 3.1
 Style; not discussed, pp8,9
 Subcommittee(s) in references, 3.1.3.6
 Subordination; govt agencies, 3.1.3.6
 Subscripts to atomic elements, 4.4.1
 Subtitle, See Title
 Subtopic, 2.3
 Summary, 1.7
 Superscript
 In citation, 3.1.2; 3.1.2.1; 3.1.2.5
 Multiple; in references, 5.4.9
 To atomic elements, 4.4.1
 Syllabus, See Bullets
 Symbol(s)
 Degrees, 4.3.3
 In footnotes, 4.1.1; 4.1.5
 In measurements; repeated, 4.3.3
 In nomenclature, 1.8
 Need to cite, 3.1
 System; metric, 5.4
 Table(s)
 Callouts, 4.2.2.1
 Decimals, 4.2.2.3
 footnotes in, 4.1.2
 Form, 4.2.2
 In table of Contents, 1.5
 Placement of, 4.2.2.2
 Tabular
 Described, 4.2.2
 Table of Contents, 1.5
 Technical
 Abbreviations, 4.4.1
 Journals, 3.1.3.7
 Library; Sandia, 4.6
 Reports/anachronisms, 5.4
 Terms, 3.3
 Temperature; kelvins, 5.4.1
 Tera-; preferred to million, 5.4.15
 Term(s)
 In Glossary, 3.3
 In index, 3.5
 Terminal; periods in bullets, 2.7
 Theses; cited, 3.1.3.8
 Time
 How expressed, 4.3.9
 24-hour clock, 4.3.9d, c
 Title
 Cited, 3.1.3.1f; 3.1.3.2a
 Definitive, 3.1.3.6
 Foreign, 3.1.3.2c
 General, 1.4; 3.1.3.5
 In Bibliography, 3.4.1.1b; 3.4.1.2
 Of Appendix, 3.1.3
 Of Article, 3.1.3.2b
 Of figure, 4.2.1.3
 Of periodical/journal, 3.1.3.7
 Of Sandia Report, 3.1.3.9
 Of table, 4.2.2.2
 Page, 3.1.3.1a; 3.1.3.2a; 3.2.3
 Short, 3.1.3.9; 3.1.3.10

Sub-, 3.1.3.2a
Ton; metric, 5.4.5
Tonne, 5.4.5
Torr; discouraged, 5.4.8
Translation of title, 3.1.3.2c
Translator; cited, 3.1.3.1; 3.1.3.1d
Trivia, 5.

Underlineation
Reference titles; 3.1.3.2; 3.1.3.2b
in journals, 3.1.3.7
in Sandia Reports, 3.1.3.9
Run-in sideheads, 2.4

Unit(s)
Military, 4.3.5
Modifier, 5.2.1.1
Of measure, 4.3.1.1
Of time, 4.3.9
Validation, 3.1

Verb(s)
Nouns and adjectives as, 5.1; 5.3.2
Verbosity, 5.1
Voice; active, 5.1
Volume numbers in references, 3.1.3.7a
-wise, See Jargon

Year
Abbreviated, 4.3.9b
Fiscal, 4.3.9c
In facts of pub, 3.1.3.3f
In journal citations, 3.1.3.7c
Without comma, 4.3.9a